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L'EXPLORATION DE LA MER

RAPPORTS
ET
PROCÈS-VERBAUX DES RÉUNIONS

VOLUME XXXIX

REPORT OF THE
NORTH-WESTERN AREA COMMITTEE
FOR 1924 AND 1925

(RAPPORT ATLANTIQUE, SECTEUR NORD-OUEST, 1924-1925)

PUBLISHED BY

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IMPRIMERIE J. JØRGENSEN & CO. * IVAR JANTZEN

Introduction.

At the Meeting in Paris in October 1923, it was agreed by the Council, at the suggestion of the Danish Commission (see Procès-Verbaux XXXII, Appendix II p. 72—76) that a special Committee, »THE NORTH ATLANTIC COMMITTEE«, should be formed for the area round Iceland and the Faroes, this area being one of very great importance to the fisheries of North-western Europe.

The following General Programme was adopted by the Council for the operations of the Committee:

»The Committee will investigate hydrographically and biologically the North Atlantic region north of Rockall Bank with special reference to the Cod, Haddock, Halibut, Plaice and Herring.«

As to these fish the various countries do not take an equal interest in the same species. France for instance does not care much for the Iceland herring, and Norway not for the Iceland plaice.

Fishery work within the area in question may be done on various lines:

1) By sending out research ships able to make all sorts of special investigations.
2) By sending out observators or measurers onboard commercial fishing vessels or inspection ships.
3) By having measurements or other observations made a shore, on fish landed from the area.
4) By supplying information of a statistical nature, of fish caught in the area.

Prof. JOHS. SCHMIDT was elected as Chairman, and the following members were appointed for the countries wishing to participate in the work of the Committee:

Prof. Johs. Schmidt ..... Denmark
Dr. E. S. Russel ..... England
Dr. Ed. le Danois ..... France
Mr. Andvord, the Norwegian delegate ..... Norway
Dr. Alex. Bowman ..... Scotland
(see Procès-Verbaux, Vol. XXXII, p. 14—15 and p. 28—29).

The Committee held its first meeting in Paris, on the 5. October 1923.

The Programme of the North Atlantic Committee for 1924 was accepted by the Council in October 1923 (see Procès-Verbaux XXXII, p. 28 [3]):

Denmark:

a) Hydrographical-Biological cruise with research ship to Iceland and Faroes. b) Hydrographical-Biological observations to be made from warships stationed at Iceland and the Faroes. c) Analysis of commercial catches made in the area of the Committee.

England:

a) Analysis of commercial catches made in the area of the Committee, b) further statistical information regarding the product of the fisheries landed in England.

France:

a) Hydrographical-Biological observations to be made from warships stationed at Iceland. b) Statistical informations concerning Cod.

Norway:

Programme to be arranged.

Scotland:

a) Hydrographical-Biological cruises with research ship from West of Scotland to the Faroes. b) Analysis of commercial catches.

The work carried out in 1924 is briefly described in Procès-Verbaux XXXIV, p. 58—60.

See also Administrative Report for 1924, this Report p. 9.

Finally, the following Programme for 1925 was adopted by the Council at the Meeting in Copenhagen in September 1924 (see Procès-Verbaux XXXIV, p. 30—31):

Denmark:

1. Marking Experiments with Cod at Iceland. — 2. Pelagic hauls during the spawning season of the Cod at Iceland, and at the Faroes. — 3. Con-

tinued hydrographical work at a fixed station in Faxe Bay, Iceland, to study the hydrographical conditions all the year round.

England:

1. Analyses of the size composition of catches by commercial trawlers at the Faroes and Iceland by fish-measurers. — 2. Collection of scale material from the Faroes and Iceland (under 1) for age-determination. — 3. Market measurements at Grimsby. — 4. Commercial statistics.

France:

1. Hydrographical sections at Iceland by French Cruiser. — 2. Hydrographical and Plankton work by Dr. CHARCOT (»Pourquoi-Pas«) in summer at the Faroes, Rockall etc.

Norway:

Programme to be arranged.

Scotland:

1. One cruise by Research Vessel to Iceland in June to keep the continuity of observations. — 2. Hydrographical cruises in Faroe-Shetland Channel. — 3. Biological observations at Faroe and Faroe Banks. — 4. Comparative fishing experiments with the commercial otter trawl and with a 50-feet otter trawl used by the »Dana«. — 5. Age-assessment of Haddock from Faroe and Iceland: a) Collections by fish-measurers. b) As ascertained from analysis of catches from Aberdeen market.

The work carried out in 1925 is briefly described in Procès-Verbaux XXXVIII, p. 88—89.

See also Administrative Report for 1925, this Report p. 16.

At the Council Meeting in Copenhagen in September 1925 the Area Committees were reorganised. Under the new arrangement, the name of the present Committee was altered to

»THE NORTH-WESTERN AREA COMMITTEE«

and the following boundaries laid down for the area in question:

On the east: (line of demarcation from the area of the »North-Eastern Area Committee«): the 1000 metre line as far as the eastern edge of the Wyville-Thomson ridge;

On the south (line of demarcation from the area of the »Atlantic Slope Committee«): Rockall.

On the south-east (line of demarcation from the area of the »Northern North-Sea Committee«): the 200 metre line from the eastern edge of the Wyville-Thomson ridge to west of the Butt of Lewis.

Prof. JOHS. SCHMIDT was elected as Chairman, and the following members were appointed for the countries wishing to participate in the work of the Committee:

Prof. JOHS. SCHMIDT	Denmark
Dr. E. S. RUSSEL	England
Dr. ED. LE DANOIS	France
Mr. OSCAR SUND	Norway
Dr. ALEX. BOWMAN	Scotland

(see Procès-Verbaux XXXVIII, p. 15, 22—23, 36 and 58—59).

The following Programme for 1926 was adopted by the Council at the Meeting in Copenhagen in September 1925 (see Procès-Verbaux XXXVIII, p. 42—43):

Denmark:

From the »Dana«: 1. Special Trawling investigations at fixed stations at Iceland and Faroes. — 2. Stomach contents of Herring should be studied in relation to the Plankton.

From various ships: 3. Continuation of Hydrographical and Biological investigations at one or more fixed stations in Faxe Bay. — 4. Continuation of marking experiments with Cod and Plaice.

England:

1. Fish measurements and otolith collections. — 2. General Statistics.

France:

1. Hydrographical observations from the French cruiser at Iceland. — 2. Provisional Hydrographical and Biological work from the »Pourquoi Pas« by Commandant CHARCOT.

Norway:

1. Collection of Halibut material.

Scotland:

1. Fish measurements and otolith collections. — 2. General Statistics. — 3. Trawling investigations at Faroes and West of Scotland.

The present Report is the first that has been issued by the Committee, and deals with work carried out in 1924 and 1925, using also material from previous investigations carried out by Denmark in Iceland and the Faroes during the years 1903-1913.

Administrative Report for 1924.

The following work has been carried out by the various countries:

England:

In the course of trawler voyages to Iceland and the Faroes in May—June, measurements of cod, haddock, plaice, halibut and some few other species of fish were made. Also, measurements of fish from Iceland and the Faroes in the market at Grimsby.

Finally, I have received detailed statistics of the English halibut fishery in Iceland and Faroe waters for 1923.

I take this opportunity of expressing my best thanks for the valuable material thus contributed by England.

France:

Hydrographical investigations were carried out from the cruiser »Ville d'Ys« in Iceland waters during the month of May.

Norway:

Hydrographical research from the M/S »Johan Hjort«.

Scotland:

From the Fishery Board for Scotland, I have received a statement of the quantity of halibut landed in Scotland monthly during 1923 from the area of the North Atlantic Committee.

Further, material has also been received in measurements of cod caught at the Faroes in May by the »Explorer«.

The »Explorer«, together with the »Dana«, was occupied during the month of May with a very thorough hydrographical survey of the Faroe Channel, i. e. the waters between the Faroes and the Faroe Bank on the one hand, and Scotland-Orkney-Shetlands on the other. The two vessels made numerous sections of the Faroe Channel, and at each station, serial measurements of temperature and salinity from surface to bottom were made (see below).

Denmark:

During the spring of 1924, from the 3rd to the 14th of May, hydrographical investigations were, as mentioned, carried out in the Faroe-Shetland Channel, from the Scottish marine research vessel »Explorer« and the Danish marine research vessel »Dana«. Later in the summer, from 1st of June to 1st of August, hydrographical investigations were made from the »Dana« in Icelandic waters.

The material thus obtained has been dealt with by J. P. Jacobsen and Aage J. C. Jensen, whose results are published in this report p. 31.

In addition to the hydrographical material collected by the »Dana« in the waters round Iceland, a series of measurements from a station in Faxe Bay, off Akranes, have also been used. These measurements were made from different vessels, viz. the »Dana« and the Inspection Vessels »Thor«, »Islands Falk« and »Fylla«.

Further, in dealing with the material from Icelandic waters, the temperature measurements made in May 1924 by the French Inspection Vessel »Ville d'Ys« have also been used.

During the cruise of the »Dana« to Iceland, it was only possible to find time for the most essential hydrographical investigations in connection with the biological work.

The hydrographical investigations in the Faroe-Shetland Channel, however, and at the entrance to the North Sea in co-operation with the »Explorer«, were carried out on a larger scale than is customary with hydrographical observations. In this water, of comparatively slight extent, the two vessels were working day and night for 10—12 days on hydrographical investigations alone. Measurements were made at about 100 stations in all, and at some of these, the measurements were made twice.

In order to ascertain how far the results obtained from the available material are generally valid, it would be desirable to have the investigations repeated, partly at the same time of year, and also at other seasons. I have not, however, wished to suggest that the Committee, whose first task is that of fishery investigations, should, for the present, spend so much time and work on these hydrographical observations as would be needed; at any rate, not until the importance of this great work has been illustrated and further discussed.

Apart from the above named hydrographical work of the »Dana« in the Faroe Channel, and some hydrographical and pelagic observations in the northern part of the North Sea, our investigations in 1924 were carried out in Iceland and Faroe waters, with special attention to Iceland as the more important part of the area. Further, biological and hydrographical investigations have been carried out off the W. coast of Greenland by Å. Vedel Tåning, M. Sc. onboard the Danish Inspection ship »Islands Falk«.

Our biological researches have throughout been accompanied by hydrographical observations, so that we could, at any station, whether pelagic or bottom, always keep ourselves informed as to the hydrographical conditions on the spot.

In the Icelandic waters, hydrographical conditions are more or less simple and straightforward. Off the south and south-west coasts, we have comparatively warm water of Atlantic origin, on the east and north coasts cold water, partly of polar origin.

Generally speaking, there is a sharply defined hydrographical boundary line off the south-east corner of Iceland, where the Atlantic and the polar water meet.

The circumnavigation of Iceland amounts to over 800 miles.

In the course of the first few days of June, the »Dana« sailed round the greater part of Iceland, and found the hydrographical boundary as clearly marked as ever.

At the south-east and the north-west corners of Iceland, we found the 4° isotherm. A line drawn between these two points would thus — at this time — divide the sea here into two parts, one with a surface temperature above, the other with surface temperature below 4° C.

The occurrence of cod eggs and larvæ was particularly investigated, but on examining the samples we obtained of course also information as to the other species.

About April, the principal spawning season for the cod in Iceland waters, collections were made from the Danish cruiser »Fylla«. On the south coast, horizontal hauls were made, each of fifteen minutes' duration, with a tow-net, one and a half metres in diameter. Very large quantities of pelagic cod eggs were brought up in these hauls. In one sample taken on the 30th of April, close in to the western part of the south coast of Iceland (22° 49′ W., 63° 49,5′ N.), we counted 62—63,000 cod eggs[1]).

It would of course have been preferable if we could have made hauls with quantitative nets. Failing these, however, the hauls are nevertheless interesting in themselves, since they serve very well to give us at least an idea of the position.

It was in the first few days of June, that the »Dana« sailed round Iceland. By this time, the cod had for the most part finished spawning, and it was therefore the occurrence of the pelagic larvæ we investigated, at 32 stations in all, these being situated on the coastal banks round Iceland. On each station, two horizontal hauls were made, each of fifteen minutes' duration, with tow-nets of 2 metres diameter.

[1]) 145 cubic centimetres of eggs, of which 10 cubic centimetres contained 4310 cod eggs and 254 eggs of other fish.

Of the 32 stations taken (see fig. 1) abt. 10 lay in the cold water off the east and north coasts, and in none of these were any larvæ of cod or other gadoids found. The remaining stations (abt. 20), were situated in the warm water off the south and west coasts, and of these stations, only one failed to yield larvæ of gadoids, which were present at many of the stations in very great numbers. In one of the »big« stations there where 831 cod larvæ,

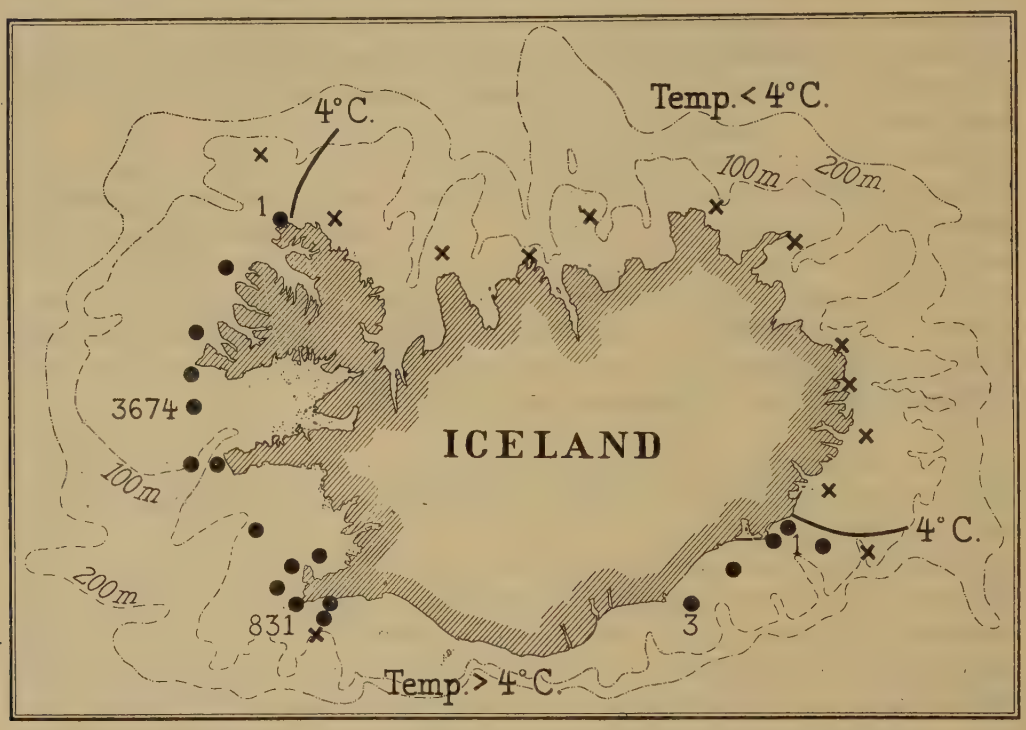

Fig. 1. Distribution of pelagic cod fry. »Dana«. June 1.—9. 1924.

• Postlarval stages of cod *(Gadus callarias)*; number of specimens per 15 minutes' haul with 2-m net indicated at a few stations. × no specimens taken.

and in another 3674 cod larvæ. We have thus very large quantities here, but it must also be borne in mind that these grounds are among the most important cod fishing centres in the world.

The spawning of the cod in Iceland waters is mainly restricted to the warmer water on the south and west coasts, and here again a certain range of the south coast, between the Westman Isles and Reykjanes, is by far the most important. It is here, too, that the great cod fishery takes place in the spring.

In accordance with the Programme of the Committee, we have, in the investigations of bottom stages of food-fishes, devoted our attention chiefly to the Cod, Haddock, Plaice and Halibut, and we have brought home a

great quantity of material, comprising about 12,000 samples of scales and otoliths, besides a much greater number of measurements.

I thought it best to endeavour more particularly to collect extensive materterial of the younger, that is to say, the first three or four year classes. These are but very inadequately represented in the catches landed by professional fishermen, and it is therefore the task of research vessels in particular to procure information as to these younger fish, which are more or less unimportant to the fishermen.

The material obtained has already been partially investigated (see the Scientific Reports, p. 31—168).

Several trawling experiments were made by the »Dana« in Iceland waters, in order to investigate the composition of the stock of fish in different places. For this purpose, we used throughout a small 50-feet otter-trawl, and our hauls were always of one hour's duration.

The object of the trawling experiments was to compare stock of fish on the fishing grounds outside the territorial limit, which are much frequented by trawlers, with that of the adjacent grounds in the territorial waters, where trawlers are not allowed to fish.

For this purpose, I selected a spot in the southern part of Faxe Bay, in south-west Iceland, where trawling is carried on all the year round. During the couple of months covered by our observations, there were on an average 17 trawlers working there day and night. The depth is fairly even, varying between 30 and 35 metres, and the course of the territorial limit here is such as to form an artificial boundary only. We had thus the same depth where we were trawling both inside and outside the territorial limit.

We made 51 hauls outside and 32 inside the boundary line, and the yield of the separate hauls at the same place was more or less uniform. I am therefore of opinion that our average figures per trawling hour are of real significance. This applies especially to the flat-fish and the haddock; in a lesser degree to the cod. In the case of the cod, the yield of the different hauls fluctuated considerably. This is probably connected with the fact that the cod at that time were seeking their food pelagically, and were constantly moving about in chase of the young sand-eels *(Ammodytes)* which were there to be found. When our trawl passed through one of these swarms of sand-eels — which was often indicated by the flocks of sea-birds that followed them — we caught many cod, whereas the next haul, passing clear of the sand-eels, would bring up few or none.

I will here merely run through the results in the case of the Plaice. These are, I think, the most interesting, especially as, in the case of this species it was almost exclusively the older, marketable fish which were brought up by our trawl.

The quantity of plaice taken by the trawl amounted to abt. 4000 specimens, the average size being 32—34 centimetres. The average weight of the specimens was abt. 410 grammes. The average size of all material in June in Faxe Bay (83 hauls) was about 33 centimetres and there were only a few specimens under 25 centimetres. The catch thus consists almost entirely of marketable fish.

The number of plaice for the whole area works out at abt. 60 per trawling hour, or reckoned by weight, at about 24 kilos per trawling hour.

Let us now see what it looks like when we take the extraterritorial and intraterritorial waters separately.

Outside the limit, the average number of plaice per trawling hour was about 14.5, whereas inside, it came to about 107. That is to say, about seven times as great (see graph p. 21). And the quantity by weight naturally shows a like difference, namely, 6.6 kilos outside, but 44.1 inside.

In other words, a trawler working this area would take seven times as long to get a full cargo of plaice outside the limit as when fishing inside.

In the case of the other species of fish also, the number taken per trawling hour was greater inside than outside the limit, but in our hauls, it is mostly the younger year-classes of the various species which are represented, and the figures are therefore not so interesting in this connection as those for the plaice.

Now I should certainly never dream of asserting, on the basis of these investigations, that the number of plaice inside and outside the territorial limit in Faxe Bay is throughout as one to seven. Nevertheless, as an example of the actual conditions in an important area, I think the figures, even when taken with all due reserve, are not without a certain interest, and do provide some food for thought.

Further, I must mention the stock of plaice in another part of the Iceland waters, for comparison with that of Faxe Bay.

I chose for this purpose one of the large bays on the north coast, Skiálfandi Bay, where I have worked a great deal, — also in earlier years, with the »Thor«, — and am familiar with the general conditions. Here — in contrast to Faxe Bay — comparatively little foreign trawling is done, and the Icelanders themselves usually catch but few plaice here. The trawling grounds with good level bottom, are here exclusively to be found inside the territorial limit. We have here a stock of plaice comparatively little fished, and it will be of interest to consider how it differs from the intensively fished stock in Faxe Bay.

We made, on this occasion, 20 hauls in Skiálfandi Bay, in July, and, as in Faxe Bay, in favourable weather. The depth was less than in Faxe Bay,

averaging a good 20 metres. The result of the 20 hauls was extremely level, almost invariably the same number of plaice per trawling hour.

On comparing the yield with that from Faxe Bay, we found that in respect of weight, the quantity per trawling hour was exactly the same, namely, 44 kilos per trawling hour.

In the matter of size, however, there is a considerable difference; the average size of the plaice here was 40 centimetres, whereas in Faxe Bay, it was only 32-34. And the average weight of the plaice from Skiálfandi Bay was twice that of the Faxe Bay fish, namely, 825 grammes as against 410.

The trawling in Skiálfandi Bay is of interest as showing an example of what a comparatively untouched stock of plaice, such as may still be found in certain remote spots, looks like. The picture is very different from that which we find in most places, where the plaice are subjected to a very intensive fishery.

Finally, I have only to mention that we have marked and liberated a large number of plaice and cod in Icelandic waters, and in Greenland waters a large number of cod. And I take this opportunity of asking the members of our Committee, to do what they can to assist us in procuring the best possible information regarding any of these fish recaptured. It seems, I am sorry to say, as if the fishermen were less inclined to trouble themselves about marked fish now than formerly. And as each of these marking experiments carried out in these distant regions represents no small amount of work and expence, we should like to get as good results as can be got.

Administrative Report for 1925.

The Chairman put forward an extract from the scientific reports available for the years 1924 and 1925 (see p. 24-30).

Cruises with research ships to the Area have been made by Scotland and Denmark. Biological material has also been collected from other ships by England, Scotland and Denmark and hydrographical observations have been made by France and Denmark (by Inspection ships). Fish-marking experiments have been carried out by Scotland and Denmark.

England:

The Committee is glad to report that most valuable material of fish measurements and samples of plaice-otoliths have been received from England. The material was collected in May at Iceland by Fish measurers belonging to the staff of the Ministry of Fisheries (and sent us by the Fisheries Laboratory, Lowestoft). Similar material from Iceland collected at Aberdeen has also been sent us from Dr. Bowman.

France:

France will probably send us a series of hydrographical observations from Iceland taken in May by the French cruiser »La Ville d'Ys«.

Scotland:

The Scottish Research-Steamer »Explorer«, under the leadership of Dr. Bowman, has worked at Iceland in June and July and has — in 54 stations situated all round the island — made a large number of various investigations: hydrographical and pelagic work, trawling and bottom investigations. The haddock material is being dealt with in Aberdeen and the cod, plaice and halibut material has been sent to me for examination. I have not yet had time to study the material in detail but I have seen enough to realise that the »Explorer« has done excellent work, and I am very glad, on behalf of the Committee, to ex-

press my hearty thanks to the Fishery Board for Scotland, and the Scottish workers, for the most important share they haven taken in the Committees work.

Fig. 2. »Explorer«. Stations round Iceland June—July 1925.
◉ Trawling. • Non-Trawling.

Denmark:

Denmark's contribution to the work of the North-Western Area Committee consists of the results of a three-and-a-half month's cruise with the »Dana« to the Faroes, Iceland and Greenland. We have — further — received valuable material — hydrographical as well as biological — from a fixed station in Faxe Bay, Iceland, taken at certain intervals throughout the year by the Danish Inspection ships »Fylla« and »Islands Falk«. The Committee is greatly indebted to the Danish Ministry of Marine for this work. The same ships have also made other observations and collections, and marking experiments with cod have been made in Iceland waters by the Icelandic Inspection ship »Thor«.

The cruise of the »Dana« lasted from the 14th of May to the 24th of August. The distance sailed was 7000 miles, and 230 stations were taken.

During the voyages from the Faroes to Greenland, and from Greenland to Iceland, hydrographical as well as pelagical and bathypelagical work was done.

In a section from the Faroes to Greenland, it was found that the warmest and saltest water occured in the eastern part of the section,

and that the temperature and salinity decreased when we moved west, towards Greenland.

As to the pelagic fish and fish-larvæ, both the species and the specimens decreased in number with decreasing temperature. Å. Vedel Tåning found, that the fish-fauna must be denoted as monotonous and poor in species (only abt. 30 species were taken); and also, save as regards a few species, poor in number of individuals on the whole; the area east of the Reykjanes-ridge, however, is somewhat richer than west of this submarine ridge.

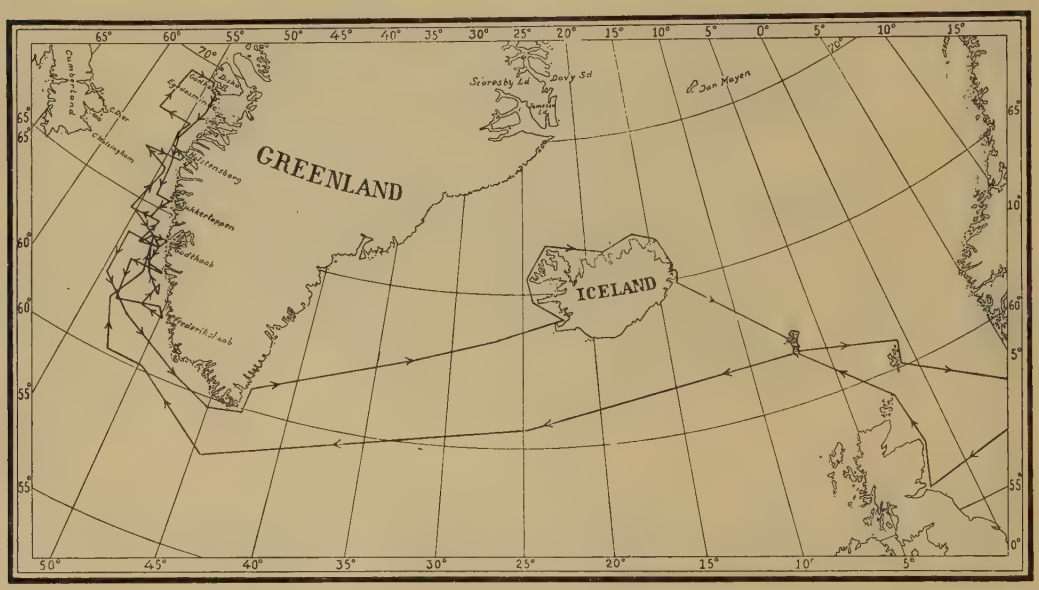

Fig. 3. »Dana«. Route 1925.

Enormous numbers of postlarval stages of the Norway Haddock *(Sebastes marinus)* were found (at stations about the 1000 metre line abt. 7000 specimens could be taken per one-hour haul with a 2-metres net). Particularly interesting is the finding of postlarvæ of the Halibut *(Hippoglossus vulgaris)* above the Reykjanes-ridge as far south as abt. 60° N. Lat. and the occurrence of postlarvæ of the Greenland Halibut *(Reinhardtius hippoglossoides)* off the east coast of Greenland, 61° 13′ N., 40° 57′ W.; the postlarva of this species was previously nearly exclusively known from Davis Strait[1]). A postlarval stage of the Torsk *(Brosmius brosme)* was taken at the same place east of Greenland. The majority of the other species found were true open-ocean pelagic species.

The »Dana« was working off the west coast of Greenland in June and July, and Professor Ad. S. Jensen, of the University of Copenhagen, was the leader of the investigations (see p. 85).

[1]) One specimen known from Spitzbergen: Crosière Océanographique »Belgica« 1905. Bruxelles 1907.

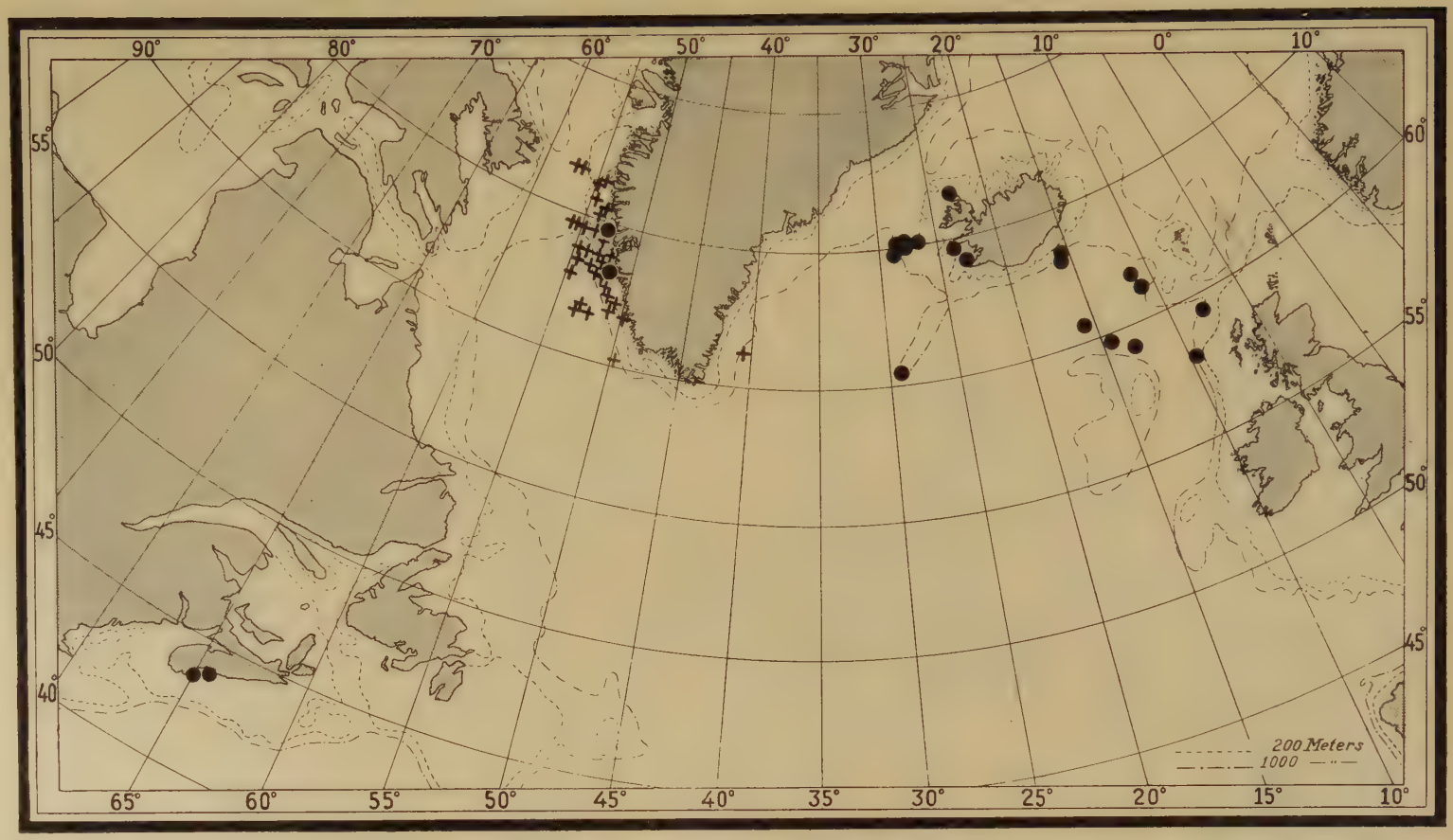

Fig. 4. • All hitherto known finds of pelagic larvæ of Halibut (*Hippoglosus vulgaris*, Flem). + Greenland Halibut (*Reinhardtius hippoglossoides*, Waldbaum). Postlarval stages. »Dana« 1925.

The work at the Faroes was carried out in May and August, the Icelandic work in August, as a continuation of the »Dana«s work in 1924, the object being to collect material for describing the composition of the populations of those species of fish with which the Committee is concerned.

In addition, hydrographical and pelagical work was carried out as usual.

Fig. 5. Distribution of pelagic cod fry. »Dana«. August 8.—14. 1925.
• Pelagic stages of the 0-group of cod *(Gadus callarias)*; 30 minutes' haul with 2-m net.
× no specimens taken.

I cannot give a detailed report now; what I can do here is to give just the outline of the work and a few charts.

The distribution of the pelagic cod-larvæ in Iceland waters was investigated in August, and was apparently the normal for that month. As we are aware, the principal spawning grounds of the cod, haddock, herring and most other important food-fishes are situated on the south and west coasts of Iceland. We did no pelagic work here in spring and early summer, but the chart (fig. 1, p. 12) from 1924 shows the distribution of the cod-larvæ during the first days of June. The crosses indicate absence, the black spots presence of cod-larvæ.

In late summer the conditions are very different, as may be seen from the chart fig. 5, which shows the distribution of the pelagic cod-

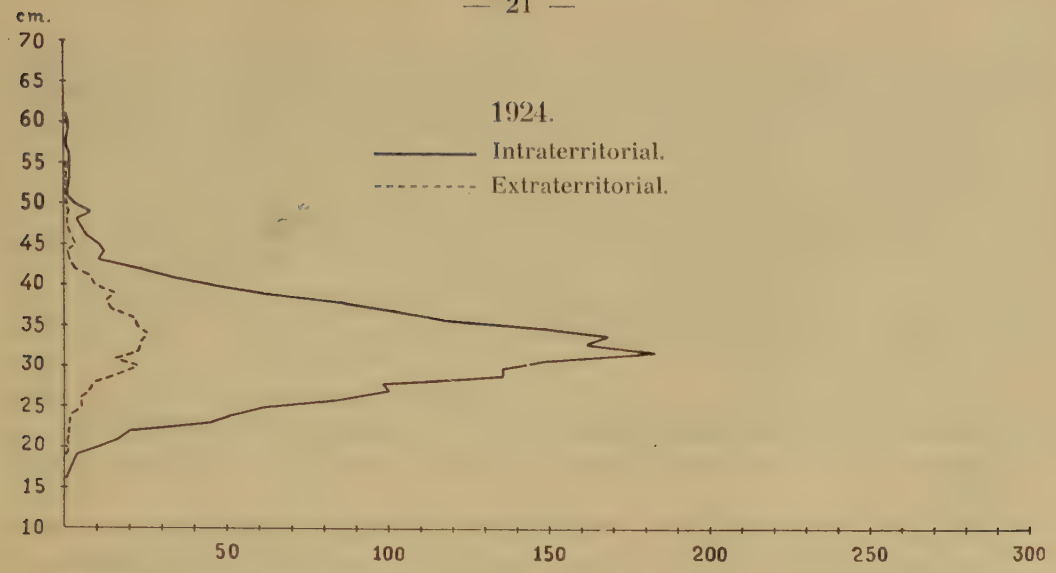

Fig. 6. Plaice *(Pleuronectes platessa). Faxe Bay.* June 1924.

	Intraterritorial	Extraterritorial
Average size in cm	32,4	33,9
No. per trawling-hour	106,8	14,5
Trawling-hours	32,75	51

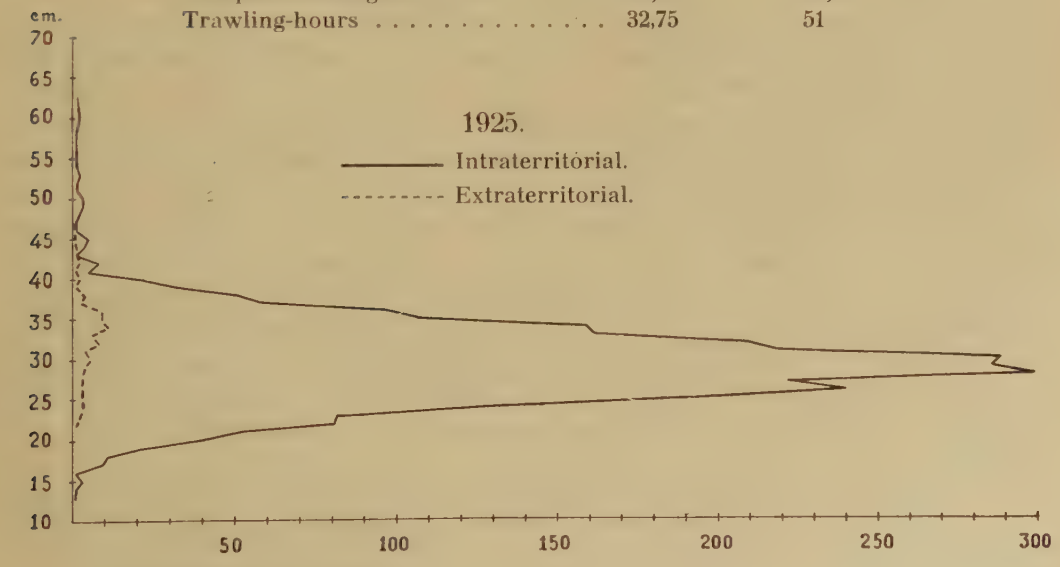

Fig. 7. Plaice *(Pleuronectes platessa). Faxe Bay.* Abt. August 1. 1925.

	Intraterritorial	Extraterritorial
Average size in cm	29,3	33,5
No. per trawling-hour	155,8	4,3
Trawling-hours	20	19

larvæ in August 1925. — On the west coast there were few or no pelagic cod-larvæ; they had already gone to the bottom or drifted away; but pelagic stages occurred along the whole North Coast and northern part of the East Coast.

As usual, we found only few pelagic halibut larvæ. The chart p. 19 (fig. 4) shows all the hitherto known finds of pelagic larvæ of this species, which has its principal centre of occurrence within the Committee's Area.

Larvæ of the summer-spawning herring were found off the west coast of Iceland, 8th—9th August, mostly under 10 mm long.

The main object of our work in Iceland waters was to continue the trawling experiments we had begun last year at some selected spots, and to compare the amount of fish on both sides of the territorial limit.

I shall only mention the results of our trawlings at Skagi, in Faxe Bay, S. W. Iceland. We trawled in about 35 metres, and had the same depth on both sides of the limit. The trawl was our ordinary 50-feet otter trawl with small-meshed net round the cod-end, and the hauls were of one hour's duration. We had 20 hauls inside the limit and 19 outside.

The result was a confirmation of what we found last year, at any rate in regard to the plaice and the haddock.

On an average, 156 plaice were caught per haul inside, against only 4,3 outside; and for the haddock, the figures were about 200 specimens inside against 10 outside. See fig. 7.

As to the cod and halibut, there was not much difference between the extraterritorial and the intraterritorial hauls, but the material obtained was too small to say anything for certain.

This work must be continued, and trawling experiments must be made, not only in summer — as hitherto — but also in winter. We must, further, make marking experiments and investigate the quantity of available fish-food — outside and inside the limit — before we can say, to what extent the territorial limit, this imaginary line, is responsible for the enormous richness, the enormous preponderance of the territorial waters in regard to the quantity of fish of the bottom-feeding species like the plaice and haddock.

Besides the pelagic hauls referred to on p. 20 we made a series of hauls in Faroe and Iceland waters with the Danish eel-seine, which is an excellent implement for catching the younger year-classes of the Cod.

Fishery and oceanographical investigations have been carried out by the Danish Commission in this area during the last 23 years, and I think we may be allowed to say that they have brought us a fairly good general idea of the distribution of food-fishes, horizontal and vertical, of their spawning sea-

sons and spawning regions, larval development and so on. And we have learnt that Iceland and Faroes are self-contained areas. But as to details, our knowledge is quite insufficient. We need not, however, feel ashamed of this, I think.

The investigations in Iceland and Faroe waters have hitherto been of a more or less casual nature, and this was quite natural as long as the Council had not taken steps to organise fishery investigations in these Northern waters.

Now that this has been done, through the formation of the North-Western Area Committee, the position is very different.

We may now hope that our Committee will be able to do work in connection with the North-Western Area Committee regularly every year by means of research vessels or in other ways.

The position is therefore, undoubtedly, better than before, but, still, we must not forget that our area is very large, and the available means unfortunately not correspondingly large.

We must, therefore, be prepared to centre our attention upon certain important fishery problems and to stick to them, at any rate for a certain amount of time.

According to my opinion, the most important task before us — at any rate at the present time — will be to collect material which may enable us to describe — by year-classes — the composition of the stocks or populations of our five important species of fish, and to follow them from year to year.

This may be felt as a somewhat tiresome task or working programme but I have no doubt that this work must be done and done for some years, at any rate.

But I wish to point out that this scheme, of course, does not prevent us from taking up other tasks from time to time according to the wishes of the members when circumstances permit. — Only we ought to take care not to be too diffusive to begin with.

As to the places from where material should be collected for the purpose of analyses of the stock of fishes I suggest the following four for Iceland, — all places where trawling can be made:

For the South coast: Ingólfshöfdi.
For the West coast: Skagi in Faxe Bay.
For the North coast: Skiálfandi Bay,
and for the East coast: Hjeradsflói.

For the Faroes I suggest that the isolated Faroe Bank and the banks surrounding the islands be treated separately.

The work of »Dana« will be centred upon trawling experiments, especially in Faxe Bay, in connection with the programme of the Committee,

but we also expect to undertake a detailed investigation of the food of the Herring which consists mainly of the little copepod *Calanus finmarchicus.*

Our intention is to compare the contents of the stomachs of the herrings with the plankton of the water where the herrings are caught, and to try to find out, if possible, if there is any connection between the amount of plankton and the presence of shoals of herring.

This summer we have already made quite a preliminary investigation of that sort. It cannot be regarded as more than a first orientation but — so far — it seems rather promising.

Round Iceland, we made a series of horizontal hauls of five minutes' duration with a silk net, and estimated the quantity of *Calanus finmarchicus* caught. The result was that there seemed to be a connection between the quantity of Copepoda and the presence of Herring.

Survey of the Scientific Reports.

At the Council Meetings in 1924 and 1925, I gave a short preliminary account of the work of the Committee during these two years. This work has now been embodied in the Committee's Report for 1924 and 1925, and I give in the following a brief summary of the contents of the scientific reports.

The hydrographical part of the Report deals first and foremost with the hydrographical observations in the Faroe-Shetland Channel.

The observation material is published in the »Bulletin Hydrographique« for 1924, and is dealt with in this Report p. 31—84.

The investigations in the Faroe-Shetland Channel from 3rd to 14th May 1924 have shown that the water at the surface is composed of Atlantic water, that at the bottom being bottom water from the Norwegian Sea. The Atlantic water was most prominent in the south-eastern part of the Channel, where it reached down to depths of 400—500 metres, and least pronounced in the north-western part, where in some places it has disappeared altogether. The bottom water reaches nearest the surface in the middle of the Channel, up to 400 metres depht. Between the Atlantic water and the bottom water there is an intermediate layer, as a rule of about 500 metres thickness. This intermediate layer is formed by the mixing of Atlantic and bottom water with water introduced from the East Icelandic Arctic Current.

Characteristic mixings take place between the layers. These are met with more especially in the shallower parts of the area in question, out to a depth of abt. 200 metres, but also out in the middle of the Channel there is a zone where the mixing is very pronounced, owing to eddy formation in connection with the strong currents.

An investigation by the Bjerknes method of the currents arising from different specific gravity of the water showed that the warm, salt Atlantic water is carried to the upper layers in the channel from the area west of the Faroes. When the current carrying this water reaches down to the south-eastern slope of the channel, it turns towards the NE and moves, in a winding course, along the slope, flowing out for the most part from the channel in a north-easterly direction.

This main current in the upper layers of the channel gives rise to various cyclonic and anticyclonic movements of the water.

A branch of it moves out from the channel into the North Sea between the Orkneys and the Shetlands, so that the water coming in here must be presumed to originate from the area west of the Faroes. Between the Orkneys and Scotland, the coastal water is carried into the North Sea from the NW coast of Scotland.

Deeper down (300—500 m) the water moves into the channel from the west, keeping along the south-eastern slope for the most part in the same direction as the surface current.

The surface and deep water currents are thus in all essentials of like direction in the south-eastern part of the channel. This is not the case in the north-western part. Here, we find a south-westerly movement in deep water along the north-western slope of the channel, but at the surface, only such movement in the northern part of the channel, where, in conjunction with the main current in the south-eastern part of the channel, it forms part of a cyclonic water-movement.

Investigations in Iceland waters were made from 1. June to 1. August, *inter alia* at the following localities: 1) South of Reykjanes Peninsula, 2) West of Snæfellsnes, 3) Near Cape Horn, and 4) North of Eyjafjord.

Some of these investigations were repeated two or three times, and it was thus possible to determine the distribution of the coastal water at different times.

With the aid of observations from the station at Akranes, in Faxe Bay, the annual course of temperature and salinity was determined for this locality, both for surface and deeper down (50 m.). Investigations were also made from this station as to the part played by the force of the wind in effecting mixture of the water layers. These observations are being continued.

From a station in Faxe Bay, the tide currents in these waters was ascertained by current measurements at 25 metres depth in about 12 hours.

See paper by Dr. J. P. Jacobsen and Aage J. C. Jensen, p. 31.

The biological part of the Report deals with the investigations in Greenland waters and the five species of fish to be studied by the Committee.

Greenland:

The principal object of the investigations in West Greenland waters was to study the occurrence and the life-history of the Greenland cod and first of all to settle the question whether the cod breeds in Greenland waters or whether the stock depends upon migration from other areas such as Iceland or North America.

The investigations were made off the west coast at 126 stations, situated between 60° and 70° N. Lat., that is to say both south and north of the submarine ridge which connects Greenland with America separating the deep Davis Strait from the deep Baffin Bay.

The following banks from north to south were investigated: The shelf west of Disco Island, Great Hellefiskebank, Little Hellefiskebank, Fylla Bank, Fiskernæs Bank and further a bank which was discovered and surveyed by the »Dana« and given the name of the Dana Bank.

Pelagic cod-eggs and cod-larvæ were found in June along the whole distance from Fiskernæs Bank to Holstensborg, that is to say south of the submarine ridge between 63° and 67° N. Lat. — and in July cod-larvæ, about 10 millimetres in length, occurred along the same distance.

In 1924, Å. Vedel Tåning, who worked onboard the Danish Inspection ship »Islands Falk«, found the area of pelagic cod-eggs and cod-larvæ in June — July of nearly the same extent.

North of the submarine ridge the cod-larvæ did not occur; they were here replaced by larvæ of the polar cod *(Gadus saïda)* which were caught in greater numbers than the larvæ of the Cod.

The number of cod-eggs taken per half hour's haul in a big pelagic net, was generally small, less than a hundred, with only one exception, a station situated in the inner part of the large Godthaab Fjord where the number rose to nearly 3000.

The number of cod-larvæ per haul of half an hour's duration was also small; the best hauls were made at the south end of Little Hellefiskebank, where 7 stations yielded: 16, 18, 10, 12, 19, 97 and 187 larvæ per haul.

In June, the »Dana« found very few cod on the banks, but from the beginning of July, cod were fairly abundant, especially on the Fylla Bank. — Apparently, there was a connection between the appearance of the cod on the banks and the temperature of the water. Thus, on June 8.—10., when cod were lacking, the Fylla Bank was covered by cold water, 0,2°—0,8° C. In July, when cod had appeared, the temperature had risen, and now varied from about 1° to about 2,7°. In late June 1924, when cod were abundant on the bank, the temperature was 2,5°.

Nearly all the specimens examined were large spent cod. Their average length on Fylla Bank was a little less than one meter, or more exactly, 97 centimetres, that is to say, very large cod. In June 1924 the average length of the cod was 99,6 cm on the Fylla Bank.

The net result of the investigations is, that it has been placed beyond doubt that a particular stock or population of Cod exists here, indigenous to the waters of Western Greenland. It belongs to the warmest part af the W. Greenland waters, and if we can judge from the number of eggs and larvæ taken, it must be much less numerous than, for instance, the stock of Cod in Iceland waters, where the same nets caught the cod-larvæ by thousands.

The fact that West Greenland has a particular stock of Cod reproducing here agrees well with the results of a series of biometric investigations with cod undertaken by the Carlsberg Laboratory. These showed that the Greenland cod belongs to a race which differs from all other samples so far examined in the greater average number of vertebræ and finrays.

Whether cod from other regions immigrate to Greenland we cannot say as yet, but — in order to try to find this out — we have marked a number of large cod, in 1924: 416 by Vedel Tåning and in 1925: 410 specimens.

So far, there are some records of recaught specimens (16 specimens), all of which were taken in Greenland near the place where they were liberated, and thus not giving evidence of any migration of great extent.

As to the season of the appearance of the Cod on the West Greenland Banks it seems that they appear rather late, but the date of arrival is, undoubtedly, subject to variation. As I explained before, the »Dana« did not find them in any numbers until the beginning of July, but the year before, in 1924, the »Islands Falk« found them in great numbers the 23. June, that is, about a fortnight before.

As to the results of the other investigations of the »Dana« at the W. coast of Greenland, I cannot go into details here, but may just mention a few points.

In Greenland, the number of the economically important food-fishes is very restricted. Such species as the plaice and haddock do not occur at all, and the only important species, if we do not count the Greenland halibut, are the Cod and the Halibut.

Pelagic larvæ of the halibut were found by the »Dana«, and this proves that the halibut spawns in the West Greenland waters. As usually, their number was small, only two specimens were taken.

The more numerous were the pelagic larvæ of the Greenland halibut. They were taken in no fewer than 54 stations along the whole distance from 60°—66° N. Lat., that is to say south of the submarine ridge.

The abundance of the larvæ of the Greenland halibut is a remarkable feature, especially in contrast to the conditions in Iceland, where we have never caught a single larva of this species, though the fish is common enough there.

Before leaving Greenland, I may finally mention that the »Dana« has made some trawling experiments which show the great difference of the fish faunas N. and S. of the Baffinland—Greenland Ridge. Professor Jensen

has given (p. 98) a complete list of the fishes contained in two successful hauls on each side of the ridge, and the list shows that the Atlantic element predominates in the station south of the ridge, whilst the station north of the ridge has a decidedly arctic character, in spite of the fact that the two stations are only separated by a distance of $1^1/_2{}^0$.

See paper by Professor Ad. S. Jensen, p. 85.

Halibut:

Faxe Bay, the large bay at the south-western part of Iceland has proved to be a most important nursing ground for the halibut. Young halibut belonging to the first year-classes including the III-group occur here in rather shallow water in such quantities that we may sometimes get nearly as many halibut per haul as plaice, and there is little doubt that an enormous destruction of undersized halibut is caused by the trawling operations in Faxe Bay, where trawling is carried on all the year round.

Age determinations of halibut material from Faxe Bay 1924 and 1925 show that the average size for the year-groups I—III was greater in 1925 than in 1924. Comparison with the material from 1908—09 shows that the average size of the different year-groups is considerable larger in 1924—25 than in 1908—09. The relative quantity also, of the different year-groups varies in the different years. In 1908—09 for instance, the III-group was numerically predominant, in 1924 the II-group, and in 1925, the III-group.

Trawl catches of halibut inside and outside the territorial limit in Faxe Bay (1924) showed that the relative quantity of halibut was about twice as great inside as outside the territorial limit; and expressed in weight, the catch was over three times as large in the intraterritorial waters as in the extraterritorial. The average length of halibut in the two areas was in 1924, 29,92 and 26,24 cm respectively. The cause of this difference must be sought in the fact that the larger and older specimens were, in 1924, found in relatively greater numbers inside the territorial limit.

Investigation of the food of the halibut shows that the II-group fish live mainly on different crustaceans, whereas the III-group live predominantly on fish *(Ammodytes)*. See the paper by P. Jespersen, p. 103.

Herring:

The herring material has been studied by Dr. A. C. Johansen, and he has been able to show that there are two races of herring in Iceland, a spring herring and a summer herring, which may be distinguished by several characters, for example, the number of vertebræ. Examination of samples of ripe spring herring from the south coast has shown that no character by means of which the Icelandic spring herring can be distinguished from the Norwegian spring herring is known; in both we find, for example, the same number of vertebræ, namely 57,50 on an average.

The great Iceland herring fishery takes place off the north coast in summer about August, and most of the specimens caught are herrings which have spawned in spring in the warm water off the south and west coasts.

Towards the end of the fishing season, also summer-spawning herrings occur. A sample caught in mid-September 1924 off the central part of the north coast thus proved to contain at least as many summer-spawning herrings as spring-spawning herrings. See paper by Dr. A. C. Johansen, p. 114.

Cod:

As to the Cod, the Report deals with the frequency of young cod on the north and east coasts af Iceland during a number of years.

Nowhere else, I think, have young cod been met with in such great quantities as in the cold water off North and East Iceland — in spite of the fact that very few cod-eggs are spawned here. Therefore, the stock is recruited by drift, by transport of pelagic fry from the spawning places off the south and west coasts, and therefore, the quantity must depend on the success of this drift.

Through an analysis of the materiel at hand we find that 1904 and 1908 were very successful years, whilst on the other hand 1905 and 1924 were relatively poor in young cod of the I-group. This would seem to mean, that in the preceding years, namely 1904 and 1923, the transport of pelagic fry to the north and east coasts was not successful. For a general view of the life-history of the Iceland Cod, see my paper p. 139.

Haddock:

Material for age determination of haddock, collected in the course of Danish investigations in 1903—05 in Icelandic waters has been dealt with in Aberdeen, by Harold Thompson, and shows that the growth is at its maximum on the south coast, less on the north and least of all on the east coast.

The age groups 1897, 1898, 1899, 1900, 1903 and 1904 predominate, especially 1904. This does not mean, however, that the predominant year classes are found simultaneously all round the coasts, but for instance on the south and east, or south and north, or north and east, etc.

The material from 1908 and 1909 shows that the 1904 year-group is absolutely predominant; the year-groups 1907, 1906, 1903, 1900, 1899 and 1898 seem, however, also to have been productive.

Material from 1924 shows the 1922 year-group as predominant, but 1923 and 1921, with perhaps also 1918, 1916 and 1915, were also good. Scottish investigations with Scottish material also show that 1922 and 1921 were predominant.

In addition, it seems as if the older fish, over abt. 6 years, are lacking on the north and east coasts, but not on the south. The maximum growth is found on the south coast, for fish of 1—6 years, viz:

I: 3,7 cm, II: 6,6 cm, III: 10,0 cm, IV: 8,8 cm, V: ?, VI: 2.5 cm.

more than on the north coast; the decline in length from III-group to VI-group possibly indicates migration from the north coast to the spawning grounds. See H. THOMPSON's paper p. 149.

Plaice:

Age composition of the Stock of Plaice in 1924 was investigated for West and North Iceland from samples taken in Faxe Bay and Skiálfandi Bay.

Analysis of material from intra- and extraterritorial trawling stations at depths of 30—37 metres in Faxe Bay shows, 1) that the stock from these depths in Faxe Bay was composed of the year-groups IV—VII, 2) that the same year-groups were found both at the intraterritorial and the extraterritorial station; 3) that the individual year-groups appear in about the same percentage at both places, and 4) that the somewhat greater average length for extraterritorial waters as compared with intraterritorial in 1924 (33,92 cm. against 32,38 cm.) was due to the fact that the individuals of all the dominant year-groups (IV—VII) were somewhat larger in the extraterritorial waters — not, for instance, to a numerical predominance of the oldest specimens in extraterritorial waters.

As regards North Iceland, samples from Skiálfandi Bay show that the average size of the stock here from corresponding depths to those for Faxe Bay was larger; this is due, partly to the fact that it was composed of generally older fish (VI—VIII-gr.) partly to the fact that fish of the same year-group were abt. $2^1/_2$—$4^1/_2$ cm. larger in Skiálfandi Bay than in Faxe Bay.

The average length of plaice both in Faxe and Skiálfandi Bay was in 1924 somewhat larger than at the same places in 1908 and 1903 respectively. As the intraterritorial plaice fishery must be considered to have been relatively slight, the cause of the somewhat higher average in 1924 must presumably be sought in a periodicity of hydrographical or other conditions, and not attributed to the fishery, which is believed to have given rise to the same phenomenon e. g. in Baltic and other waters.

See paper by Å. VEDEL TÅNING, p. 152.

Examination of Hydrographical Measurements from the Research vessels »Explorer« and »Dana« during the summer of 1924.

By

J. P. Jacobsen and Aage J. C. Jensen

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Introduction.

As mentioned by Prof. Johs. Schmidt in this Report (p. 10), detailed hydrographical investigations were carried out during the spring of 1924 in the Faroe-Shetland Channel and at the entrance to the North Sea between Scotland and the Shetland Isles. The investigations were made from the Scottish s./s. »Explorer« and the Danish s./s. »Dana«, the two research vessels acting in co-operation *).

These investigations represent a marked advance upon those hitherto made, in that the hydrographical stations were laid much closer together than usual, and all the measurements made within a comparatively short period of time, viz. from the 3rd to the 14th of May. The position of the stations is shown in fig. 8.

The results of the measurements of temperature, salinity and oxygen content at the different stations were published in the Bulletin »Hydrographique« for 1924, and we shall therefore, in the following, only give the results of an examination based on the measurements there given.

*) Observation material collected by A. C. Stephen, B. Sc., A. I. C., and Dr. N. C. Andersen on board »Explorer« and »Dana«.

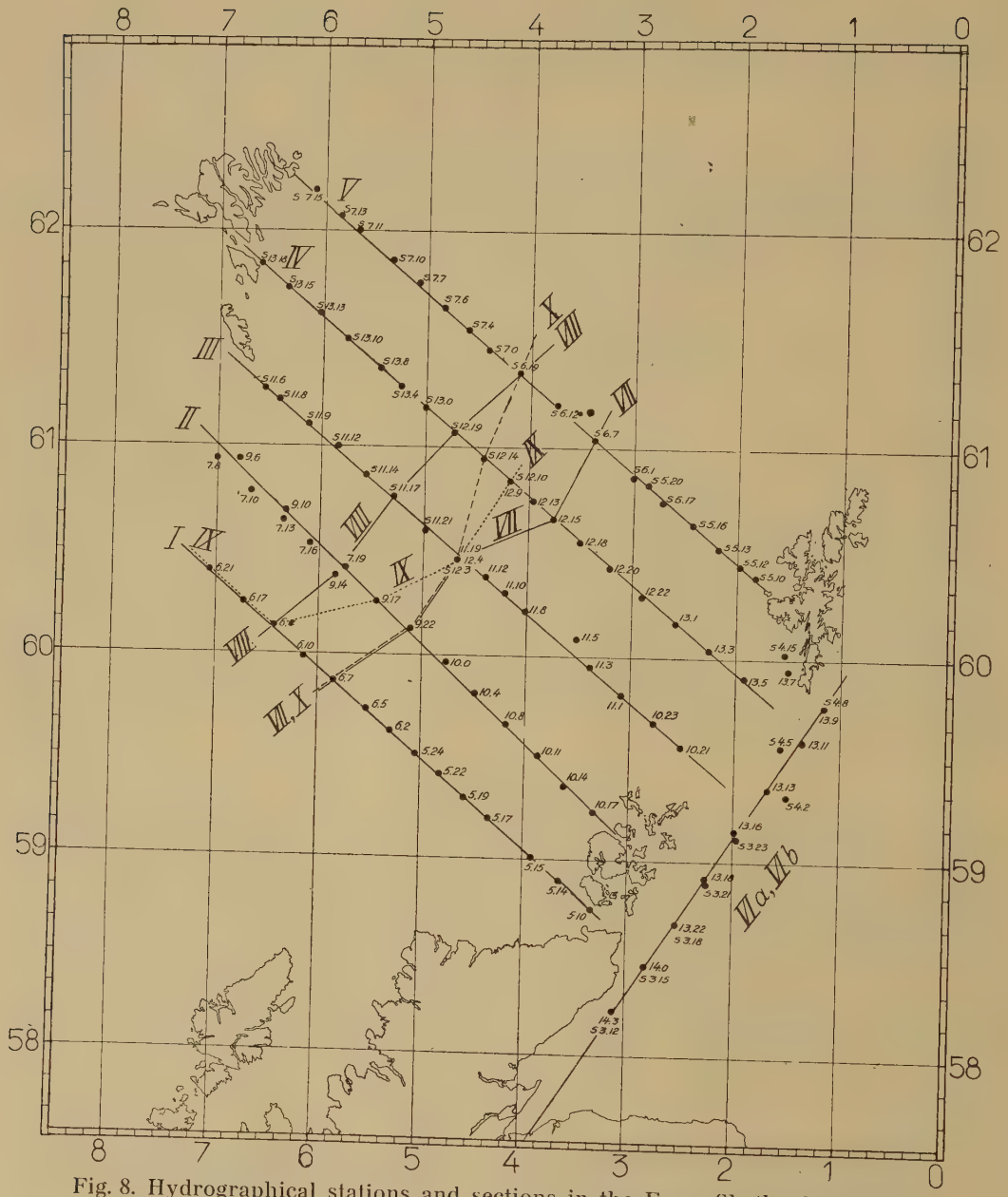


Fig. 8. Hydrographical stations and sections in the Faroe-Shetland Channel, May 1924. (Scottish stations marked S; the figures at the stations indicate date and hour shot.)

Fig. 9. Hydrographical stations and sections about Iceland May, June and July, 1924.

With regard to these results, we wish to state that we do not ourselves consider them as embracing all that can be learned from the abundance of material in question, and that further treatment of the same, in conjunction with other material from these areas and possibly with repeated measurements at sea, may perhaps modify the results arrived at to some extent; we have however, thought it best to publish the present paper as it stands, out of regard for the importance it may have in the planning of future hydrographical investigations, in these or perhaps other waters.

In addition to the observations from the Faroe-Shetland Channel and the entrance to the North Sea, reference will also be made in the following to some results of investigations made on the cruise of the »Dana« to Iceland later in the same year, in conjuction with the biological investigations.

Among the hydrographical investigations in Icelandic waters may be noted more especially the repeated measurements from a permanent Station at Faxe Bay near Akranes. Measurements have also been made here since that time, at the instigation of Prof. Johs. Schmidt, from the Inspectionships »Fylla«, »Islands Falk« and »Thor«.

In the »Bulletin Hydrographique« for 1924 will be found the measurements from that year here referred to; the position of stations will be seen from the chart fig. 9.

Finally, it should be mentioned that in dealing with these measurements from Icelandic waters, we have also made use of some observations placed at disposal by E. le Danois.

A. Hydrographical Investigations in the Faroe-Shetland Channel and at the Entrance to the North Sea between Scotland and the Shetland Isles.

1. Survey of the Distribution of Temperature, Salinity and Oxygen Content.

As already mentioned, the stations from which hydrographical observations were made in these waters are noted on the chart fig. 8. The individual stations are marked with the date and hour at which they were taken. For instance, 5. 19 means that the station was taken on the 5th of May, 19 hours after midnight, i. e. at 7 p. m. The Scottish stations are further indicated by an S, the Danish stations bearing no mark beyond date and hour.

There are about 100 stations in all, arranged in six different sections. As noted in fig. 8, the sections in the Faroe-Shetland Channel across the longitudinal direction of the channel itself are marked with the fig. I—V, that at the entrance to the North Sea by VIa and VIb, VIa indicating measurements made from the »Explorer« on the 3rd and 4th of May, and VIb measurements made from the »Dana« on the 13th and 14th of May.

Measurements having thus been made in the section referred to at abt. 10

days' interval, we are able to compare the hydrographical conditions at the two points of time. A similar comparison can be made in the case of St. 11.19, S 12.3 and 12.4, where measurements were made on two different times. Further, in the north-western portion of Section II, measurements were made by the »Dana« on the 7th and on the 9th of May, those on the former date being interrupted by a gale.

The mentioned sections I—V, VI a and VI b are shown in figs. 10-12, 14, 16-18. Further, figs. 13, 15, 19, 20, 21 show Sections VII, VIII, IX and X, which, as indicated in fig. 8 p. 32, lie chiefly in the longitudinal direction of the channel. These last sections were laid with particular regard to certain peculiarities in the hydrographical conditions in the Faroe-Shetland Channel, which will be referred to later on.

A first glance at the different sections, I—V and VII—X shows that the warm and salt water moving inward from the Atlantic through the Faroe-Shetland Channel keeps to the south-eastern part of the channel. From section III for instance, it will be seen that water of higher temperature than 8°, and salinity exceeding 35.30 ‰ is found in the south-eastern portion of this section down to a depth of 300 metres or thereabouts, whereas the 8° isotherm and 35.30 ‰ isohaline in the north-western part of the section reach right up to the surface.

In the other sections also, the warm and salt water is found in the south-eastern parts, its thickness differing in the different sections. In Section I, it extends to 300 or 400 metres' depth throughout the whole. In Section II, its extent is comparatively slight, and also in Sections IV and V.

This distribution of the warm and salt water is determined by the currents in the Channel (see figs. 33—35, pp. 67—69).

From these, it must be presumed that in the upper layers, the warm and salt water is derived chiefly from the region west of the Faroes, the deeper layers coming from south of the Faroe Bank. This difference appears to be confirmed by the oxygen analyses made.

In all Sections I—V we have, in the deepest areas, water of negative temperature, with salinity abt. 34.92 ‰. This water comes from the bottom layer in the Norwegian Sea. The course of the 0° isotherm in the different sections shows that the water from the Norwegian Sea comes in for the most part at the north-western side of the channel. Its thickness is greatest in the north-eastern side of the area, where it is found at the slightest depths, and in Section V, at St. 6.19 even comes up to less than 400 metres.

Between the warm and salt Atlantic water and the bottom water from the Norwegian Sea there is a water layer of abt. 500 m. thickness. As will later be shown, this must be presumed to consist partly of water from the East-Icelandic Arctic Current, with some admixture of Atlantic water in the upper portions, and of bottom water from the Norwegian Sea in the lower part. In Sections I—X, the water from the East-Icelandic Arctic Current may be taken as indicated

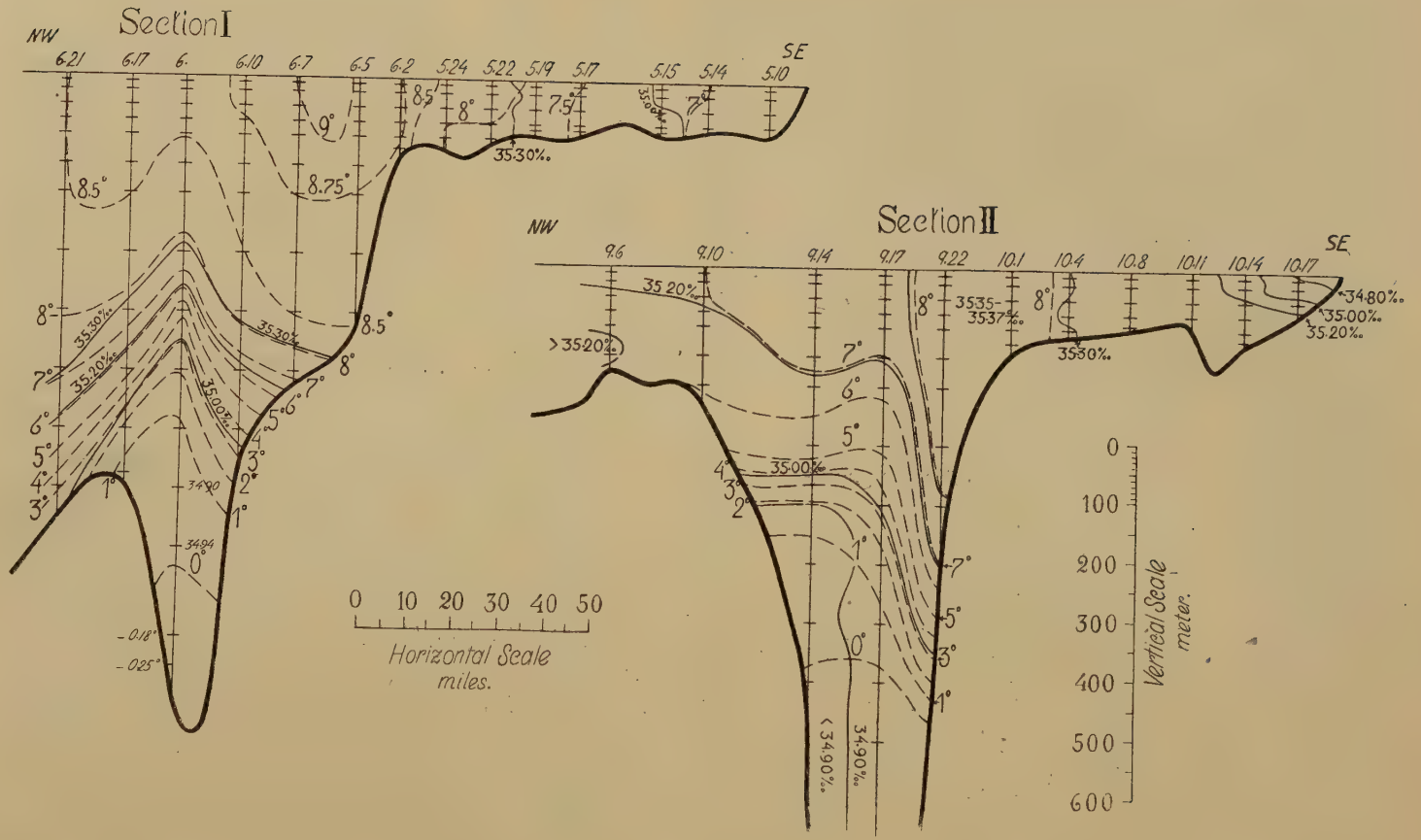


Fig. 10. Section I. Fig. 11. Section II.

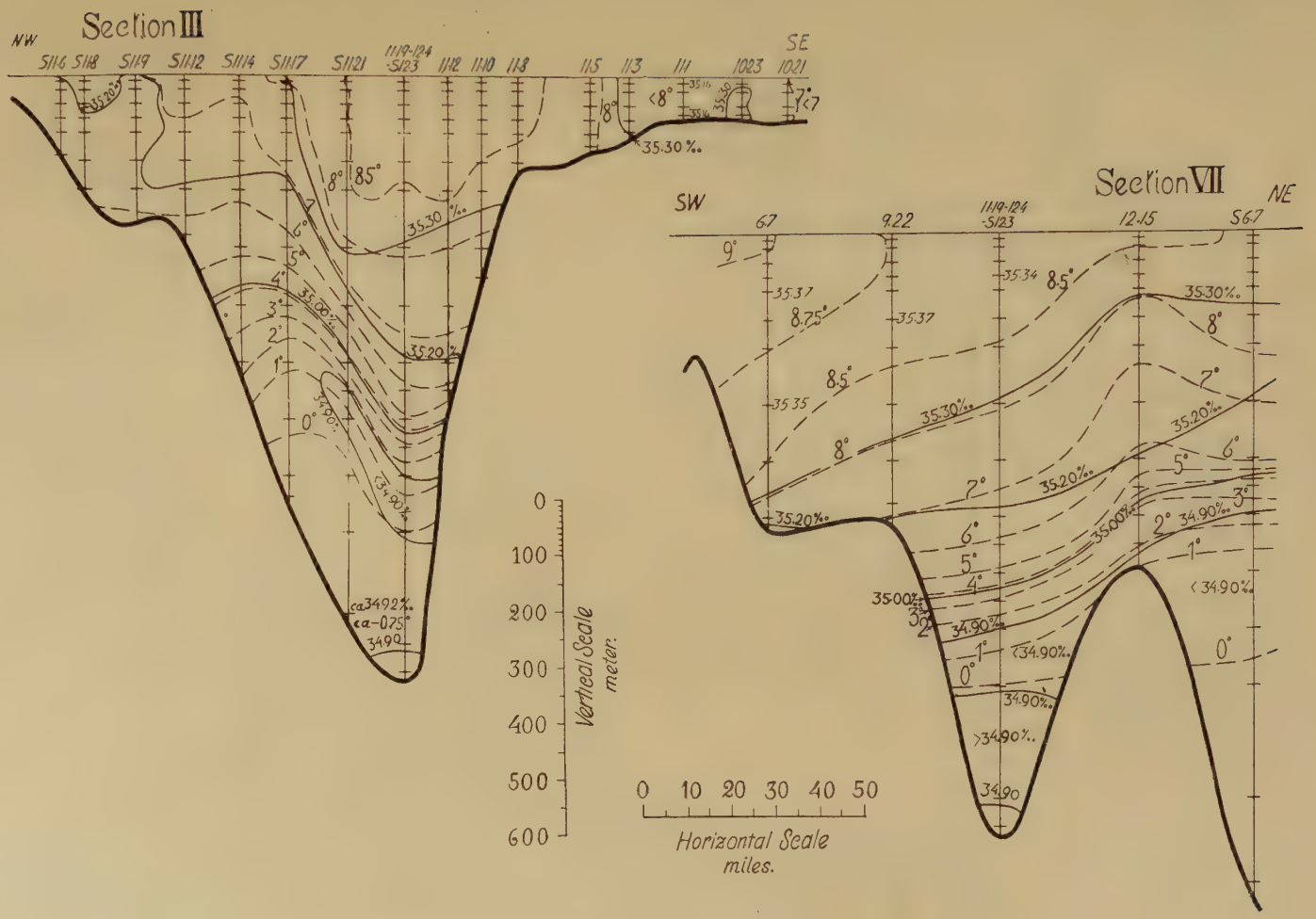


Fig. 12. Section III. Fig. 13. Section VII.

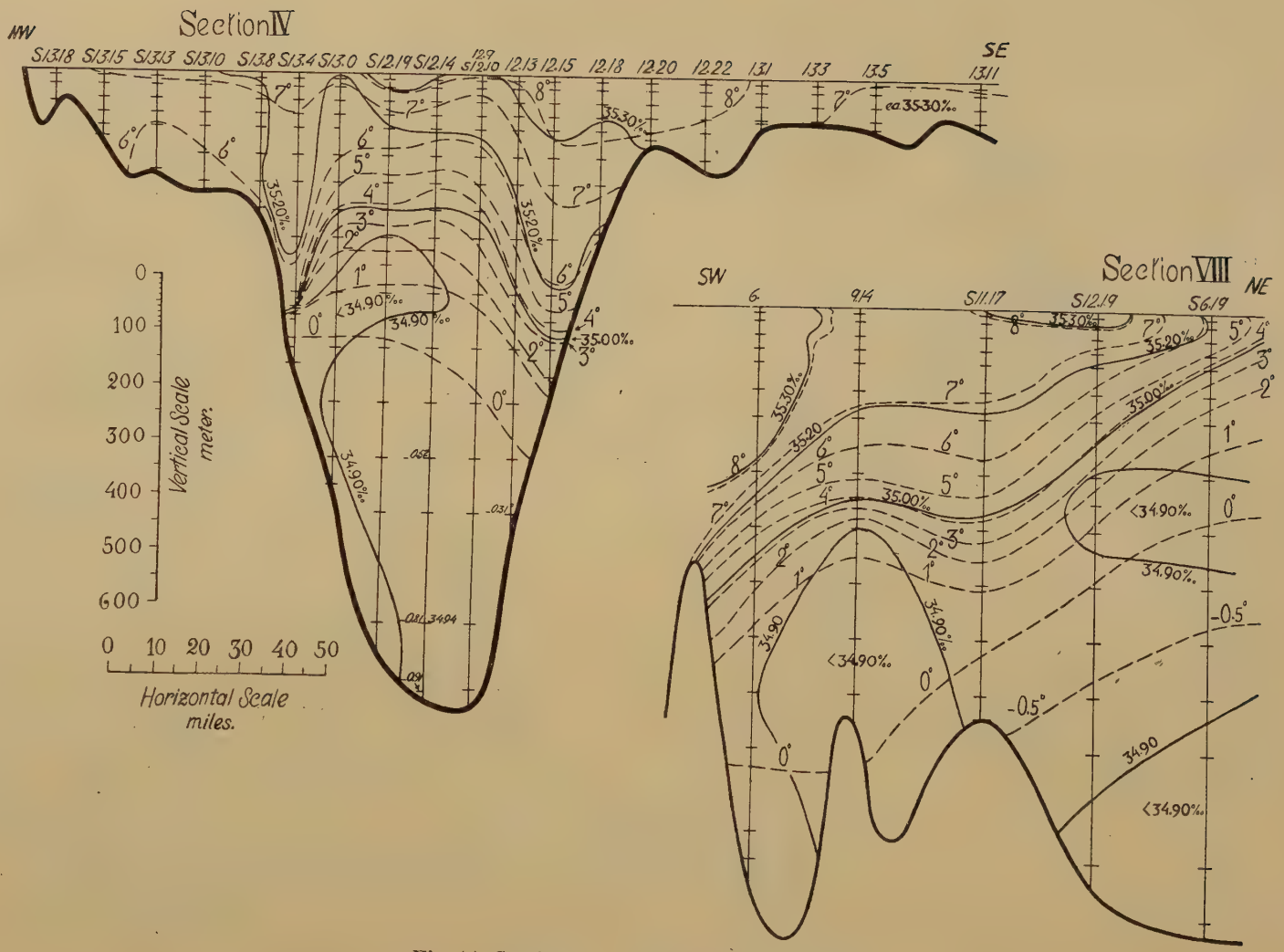


Fig. 14. Section IV. Fig. 15. Section VIII.

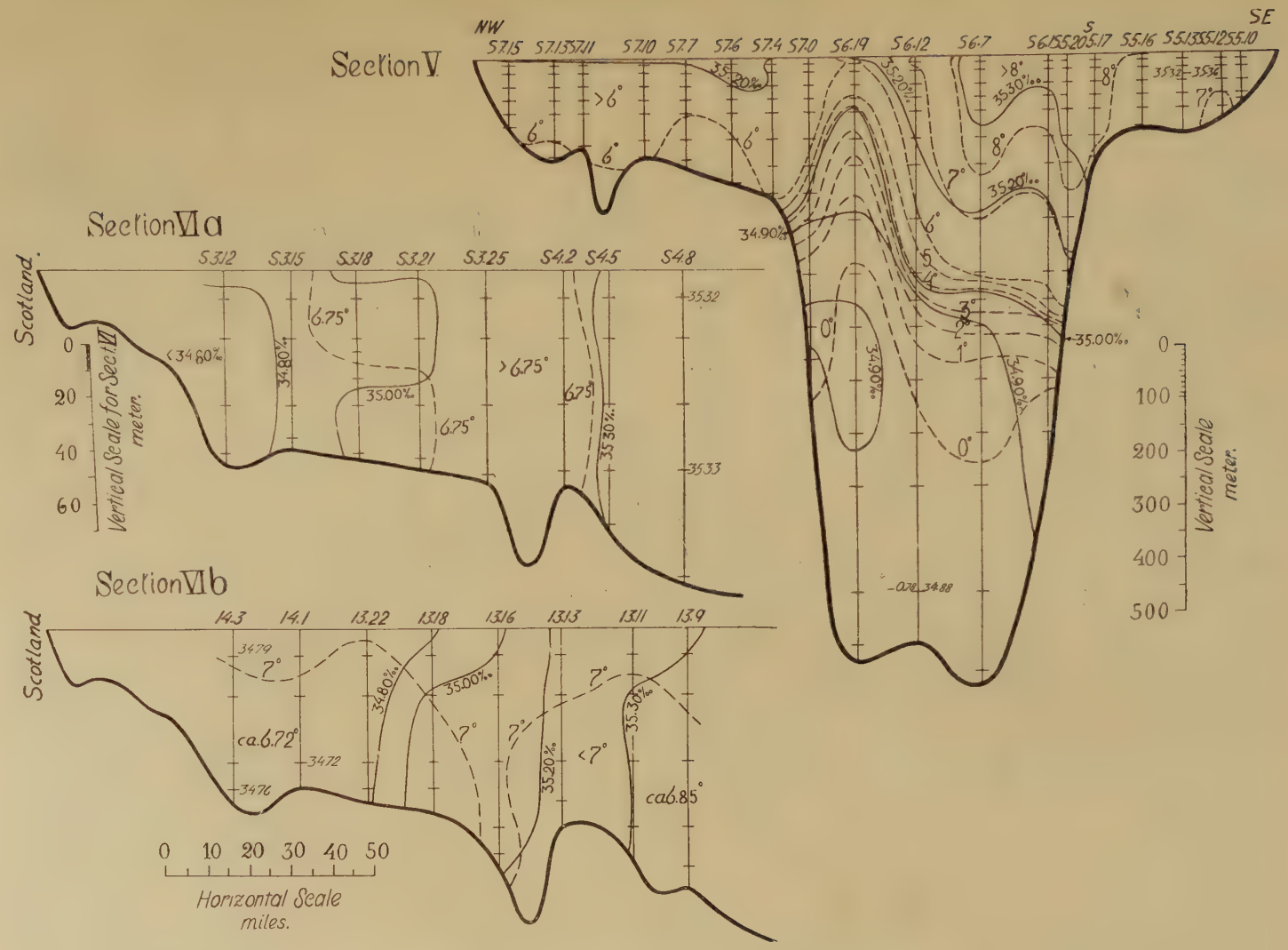
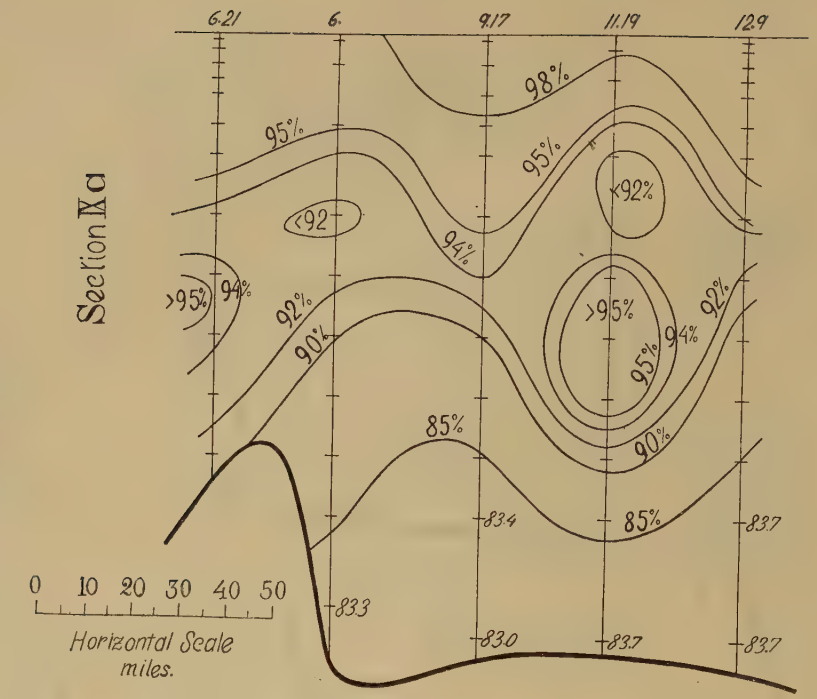


Fig. 16. Section V. Fig. 17. Section VI a. Fig. 18. Section VI b. (Section VII and VIII see Fig. 13 and 15.)



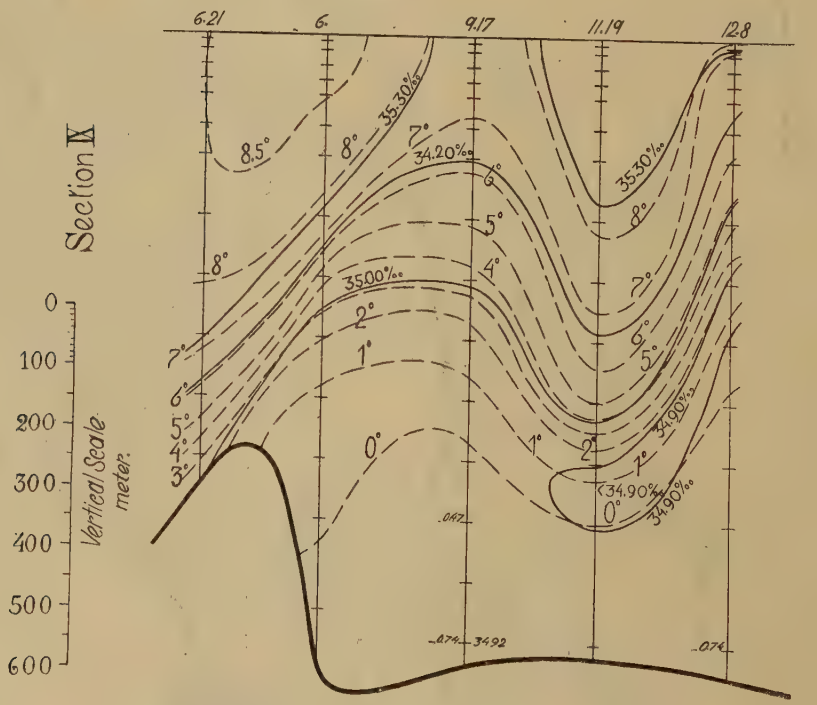


Fig. 19. Section IX a. Fig. 20. Section IX.

on the whole by water with less salinity than 34.90 ‰ where the temperature is positive.

The mixing which takes place in the mentioned water layer is produced by the currents there prevailing, and the eddy movements which attend them. It is particularly marked in the shallower portions of the area. Section V, for instance,

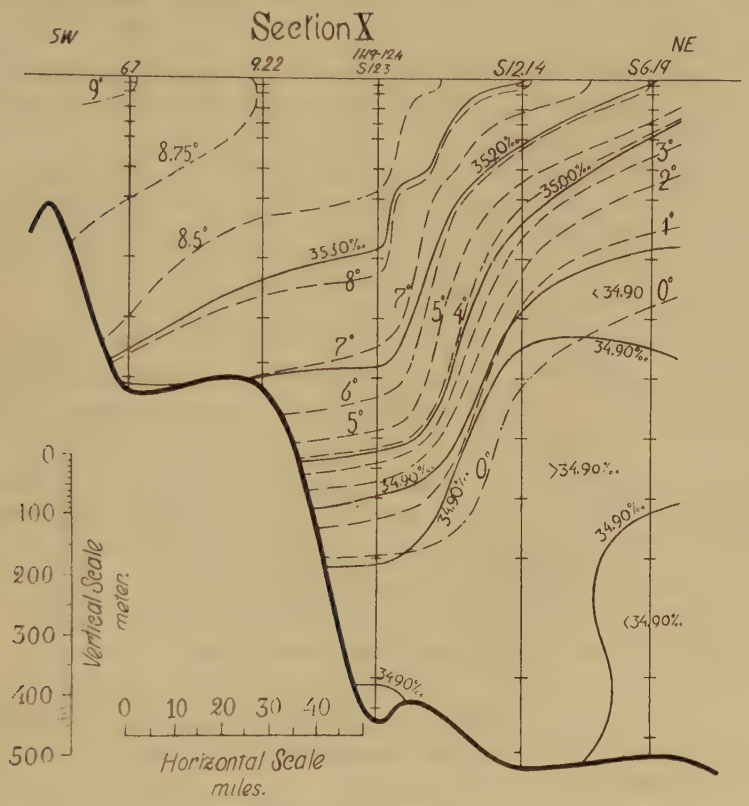


Fig. 21. Section X.

shows that a pronounced mixing has taken place in the northern part of the area investigated out to abt. 200 metres' depth, the temperature and salinity in this area differing only slightly from surface to bottom. In Section V, the influence of the mixing is apparent in the peculiar course of the isotherms and isohalines in the vicinity of St. S 7.0, which lies outside the shelf, where the mixing is comparatively intensive caused by the strong currents.

To illustrate the characteristic difference between the south-eastern and north-western portions of the Faroe-Shetland Channel as regards temperature and salinity of the water, we have drawn Section VII (fig. 13, p. 37) through those stations in the south-eastern part where the warm and salt water is most prominent, and Section VIII (Fig. 15, p. 38) through those stations in the north-western part where the

Table 1.

Stat. & Depth	11.19 1025 m		S 12.3 1085 m		12.4 ca. 1085 m		12.9 1050 m		S 12.10 1150 m		7.19 950 m		9.14[1]) ca. 750 m		S 6.19 1130 m	
m	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S_o/₀₀
0	8.84	35.34	8.82	35.36	8.86	35.37	8.14	35.35	8.38	35.34	8.34	35.37	7.66	35.25	5.90	35.21
10	.72	.34	.77	.33	.81	.37	7.70	.32	.06	.22	.32	.37	.70	.26	.97	.18
25	.69	.32	.67	.34	.70	.35	6.86	.21	7.51	.28	.36	.37	.63	.25	.79	.17
50	.66	.32	.67	.36	.69	.35	.62	.23	.07	.39	.04	.34	.03 .71	.21 .26	.52	.15
75	.67	.32	.66	.33	.69	.37	.48	.23	6.78	.21	.01	.34	6.97 7.23	.21 .26	4.95	.13
100	.66	.34	.66	.32	.66	.34	.37	.23	.21	.15	7.99	.34	7.32	.23	3.80	34.99
150	.66	.34	.64	.32	.65	.35	5.78	.16			.38	.28	.31	.23	2.69	.93
200	.67	.35	.06	.30	.57	.35	.99	.10	5.19	.09	6.59	.23	6.74	.17	1.57	.91
250									3.90	34.98						
300	.30 .17	.28 .28	.06	.26	.17	.30	3.10	34.96	.06	.90	5.48	.14	5.44	.08	0.53	.91
400	7.79	.25	7.09	.20	7.37	.26	1.37	.90	1.44	.90	4.01	.05	1.43	34.90	—0.09	.89
500	6.87 .56	.19 .19	6.53	.16	6.49	.19	0.36	.92	0.71	.91	2.28	34.97	0.45	.85	—0.42	.94
550					5.94	.17										
600	5.11	.08	4.83	.06	4.79	.05	—0.12	.90	—0.12	.91	0.69	.92	.36 .38	.85 .83	—0.56	.93
650	2.89	34.96	2.79	34.93	2.74	34.97										
700	1.76	.87	1.24	.89	1.44	.94	—0.38	.92	—0.51	35.00	—0.26	.96	.37	.87	—0.67	.93
800	0.13	.88	—0.10	.87	—0.06	.94	—0.55	.90	—0.67	34.92	—0.30	.92			—0.74	.89
900											—0.53	.94				
1000	—0.80	.92			—0.66	.94	—0.74	.92	—0.80	.89					—0.84	.89
1050			—0.75	.87												
1100									—0.88	.90[2])					—0.94	.87

[1]) Observations also made at 40 m : 7.69°; 35.25°/₀₀ and 350 m : 3.95°; 34.99°/₀₀.

[2]) The Observation is from 1120 m depth.

Table 2.

Station S 13.4 (Bottom at 538 m).

m	0	10	25	50	75	100	150	200	300	400	425	430	440	450	500	530
t°	7.45	7.31	7.12	7.05	7.02	7.00	6.96	6.89	6.25	5.75	5.33	1.74	0.65	0.41	—0.23	—0.33
S°/₀₀	35.26	35.20	35.22	35.26	35.25	35.24	35.22	35.27	35.25	35.11	35.05	35.01	34.90			34.87

least warm and least saline water is most in evidence. The position of the sections will be seen from fig. 8, p. 32.

Figs. 13 and 15 show that the isotherms and isohalines in both sections incline toward the Atlantic. In Section VII, the warm and salt water from the Atlantic takes up a considerable area, whereas in Section VIII it only appears in the south-western part Conversely, the layer of water from the Norwegian

Sea in Section VII is only of slight thickness, whereas in Section VIII it is much thicker.

In order to compare temperature and salinity at different depths from selected stations in the area investigated, the observations from such stations have been noted in tabular form in Tables 1 and 2. For the position of the stations see Chart fig. 8, p. 32.

Stations 11.19, S 12.3 and 12.4 are situated on the same spot and taken at the times indicated by the »Explorer« and »Dana« respectively. It will be seen from the table that the differences between the three series of observations are but slightly in excess of the limits of error. The stations are situated in the area where the warm and salt water extends down to comparatively great depth.

Stations 12.9 and S 12.10 are likewise situated on the same spot. They were taken almost simultaneously. The stations lie at the point of transition between the warm and cold areas in the channel.

Station 7.19 and 9.14 lie at a distance of 2 ½ nautical miles apart. Between the taking of one station and the next the weather was stormy, which doubtless contributed to the difference noticeable in the two series of observations. We still find however, in both stations, the distribution of Atlantic and North Sea water characteristic of this portion of the area.

Station S 6.19 is situated in that part of the area where the cold and slightly salt water from the Norwegian Sea predominates, reaching almost up to the surface. At this station, at abt. 90 metres' depth, there is a discontinuity layer, in that the salinity from 75 to 100 metres falls suddenly from 35,13 ‰ to 34,99 ‰. The sharpest discontinuity was found at St. S 13.4 where the salinity from 425 metres to 440 metres changed from 35,05 ‰ to 34,90 ‰, and the temperature from 5,33° to 0,65° (see Table 2).

In addition to temperature and salinity observations, we have also, from the area here in question, some determinations of the oxygen content, namely, from St. 5.19, 6., 6.21, 7 10, 9.6, 9.17, 10.0, 10.14, 11.19 and 12.9 (see fig 8, p. 32). Those from St. 6 21, 6., 9.17, 11.19 and 12.9 are the most interesting. In fig. 19, p. 40, Section IXa is drawn through these stations, with curves for the same relative quantity of oxygen expressed in percentages of the amount required for saturation. The position of the section will be seen from fig. 8, where it is marked IX.

It will be seen from fig. 19 that the water at the surface is very nearly saturated with oxygen. The slight sub-saturation at St. 6.21 and 6. may perhaps be due to observation errors, but also possibly to a cooling of the warm Atlantic water in the course of its progress through the Faroe-Shetland Channel.

The quantity of oxygen is least at the bottom, where we find abt. 83 % of the amount required for saturation. There is thus no marked sub-saturation, which was indeed hardly to be expected in a water where the mixing is so great as in the Faroe-Shetland Channel.

It is remarkable that at depths of 400—500 metres, we find a maximum of oxygen-content at St. 6.21, 6., 11.9 and 12.9.

On comparing Section IXa fig. 19 with fig. 20, showing the distribution of temperature and salinity in the same section, it will be noticed that the oxygen maximum occurs in the lower part of the warm and salt upper layer. At St. 9.17 the warm and salt water is only found in the upper 100 metres or thereabouts and here too we find the oxygen maximum has disappeared.

The oxygen maximum at 400—500 m. depth may perhaps suggest that the water here has been in contact with the atmosphere more recently than that above and below.

On examining the current charts figs. 33—35, pp. 67—69 for the surface, 300 m. and 500 m, it will be seen that the warm and salt water in the upper layers must be presumed to have come from the north, between the Faroes and the Faroe Bank, whereas the water at abt. 500 metres depth must, from the direction of the currents as indicated, and the conditions at the bottom, apparently have entered the Channel southward round the Faroe Bank. This, we may take it, explains why, on entering the Channel, it contains more oxygen than the lower layer of the water coming from the north.

In addition to the oxygen determinations used for drawing up fig. 19 p. 40, there is, as mentioned, also made some oxygen measurements at other stations; the depth at these, however, was slight, and the water, being strongly mixed, was practically saturated with oxygen at all depths. It may be noted that at St. 5.19, we found a very considerably super-saturation at the surface and at 10 metres' depth, the oxygen content being 107.4 and 105.8. This super-saturation is presumably the result of oxygen developed by vegetable plankton.

As noted on p. 35, it must be presumed that part of the intermediate layer between the Atlantic water and that from the Norwegian Sea consists of water from the East-Icelandic Arctic Current. In that part of the intermediate layer where this water is least mixed (see St 11.19, depth 700 m, and St. 12.9, depth 400 m, Tab. 1, p. 42), we find the relatively high oxygen percentage of 91.5 %.

In conjunction with the survey here given of the distribution of temperature and salinity in the Faroe-Shetland Channel, we may further draw attention to the section shown in fig. 21, p. 41, the situation of which is indicated by X in fig. 8.

The peculiar feature of this section is that it is drawn through places where the isohalines and isotherms show the most pronounced inclination relatively to the geoid surface. As the inclination of the isodense surfaces follows that of the isotherms and isohalines, the currents produced by the distribution of specific gravity will be strongest in those places through which this section is drawn (see figs. 33—35, pp. 67—69).

In our previous comments on the distribution of temperature and salinity in the Faroe-Shetland Channel, we have employed vertical sections for the graphs. In order to present the ascertained distribution in another way, however, we

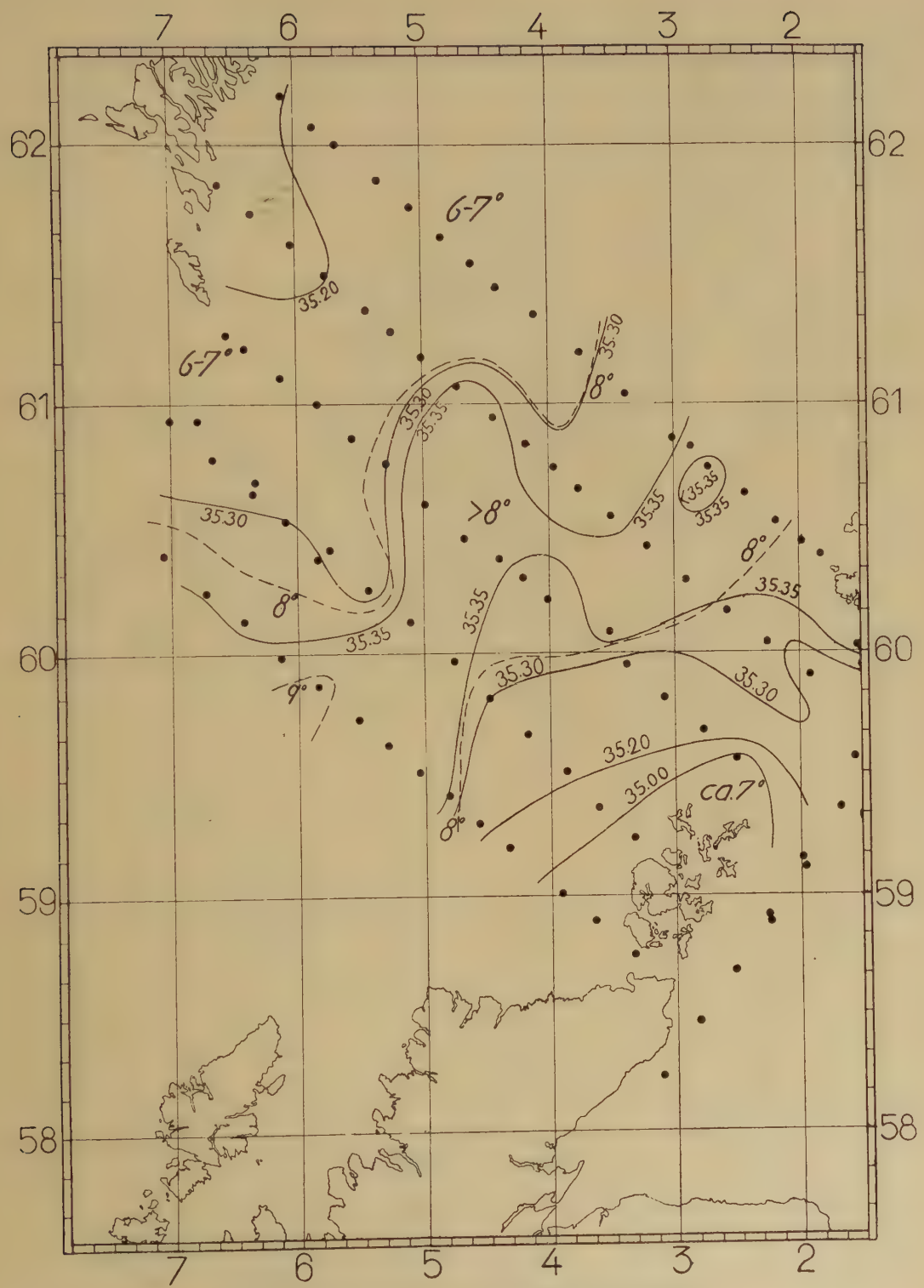


Fig. 22. Temperature and salinity at the surface.

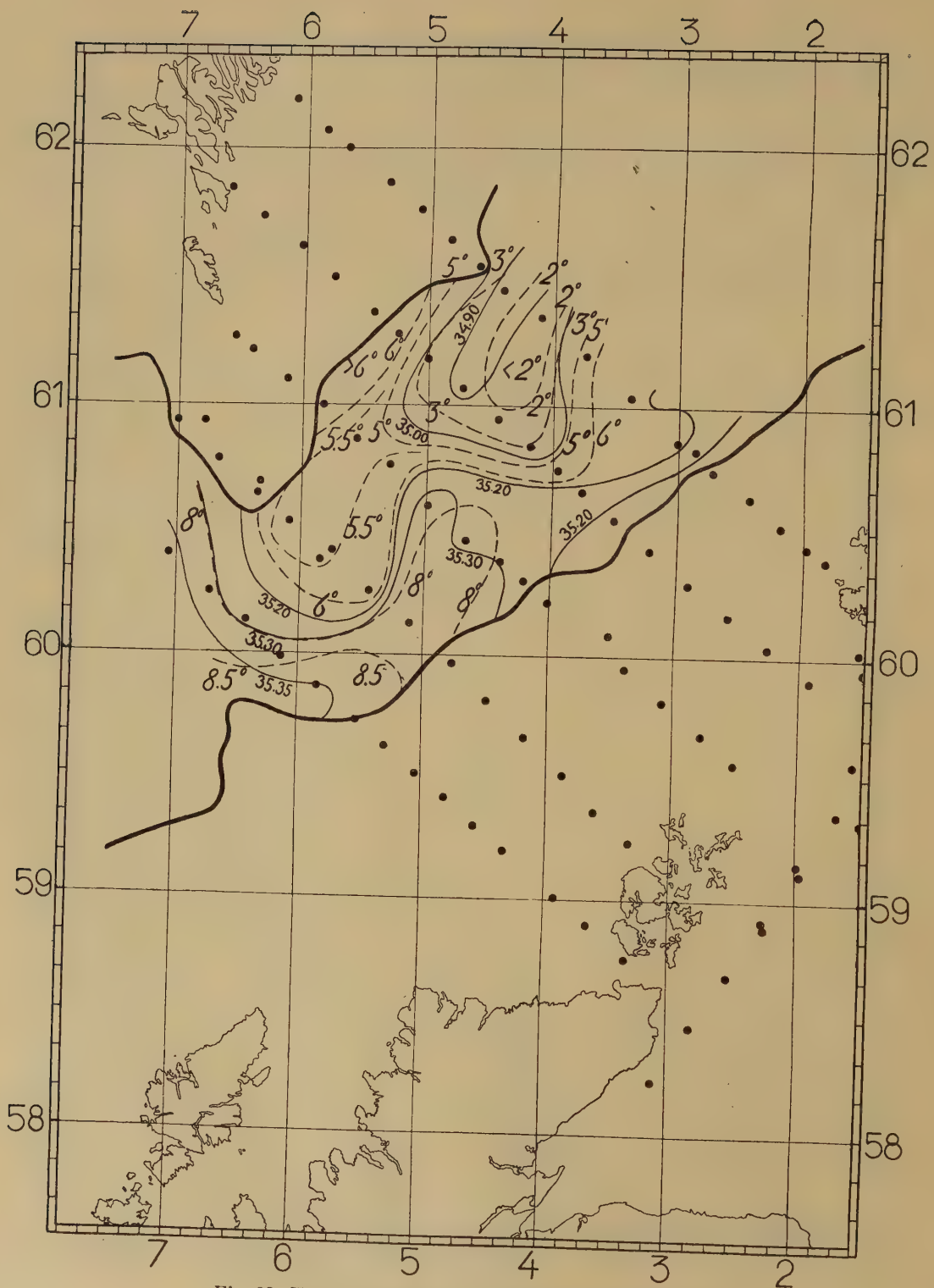


Fig. 23. Temperature and salinity at 300 meter.

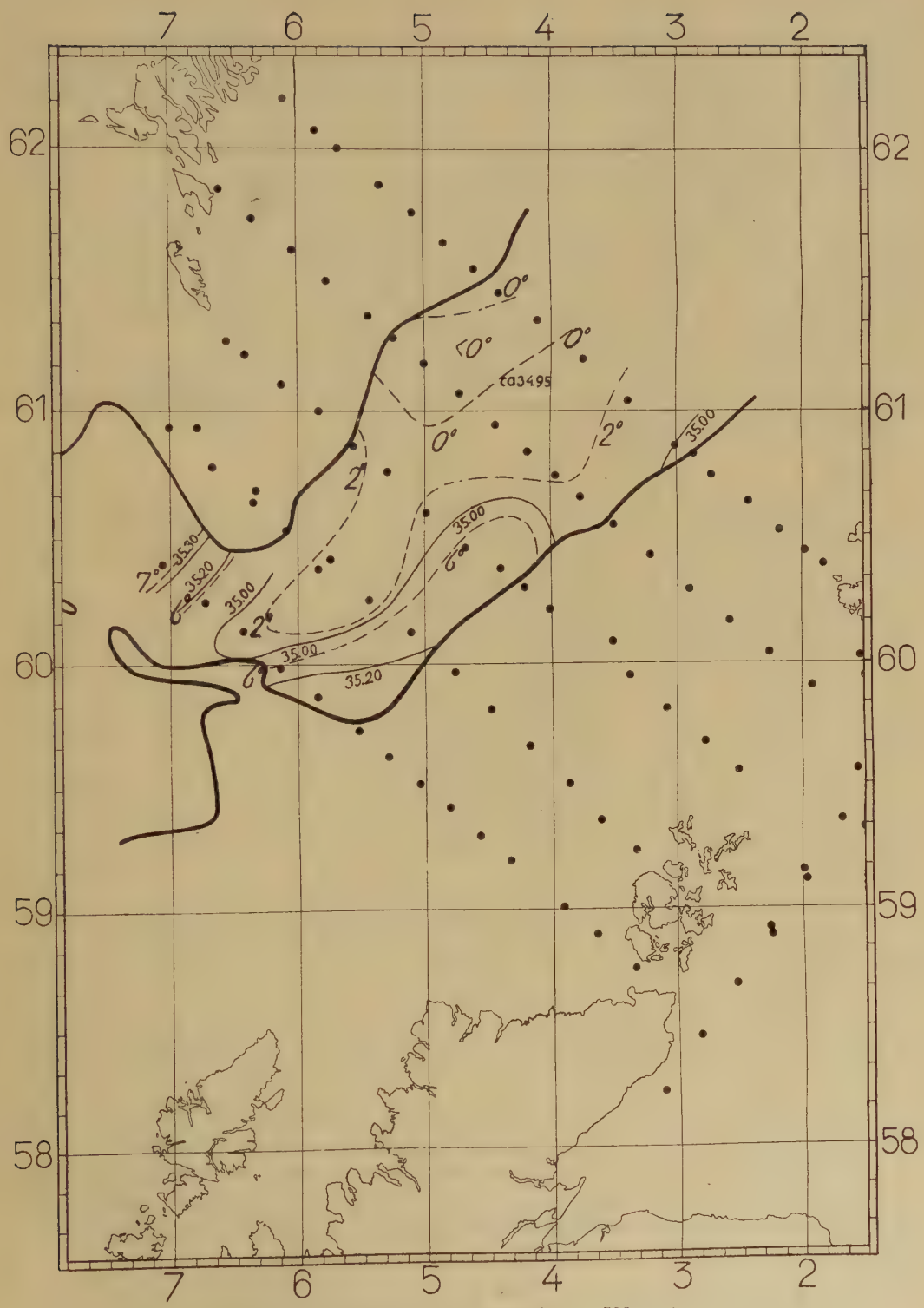


Fig. 24. Temperature and salinity at 500 meter.

have also drawn up charts (figs. 22, 23 and 24) showing the position of the isotherms and isohalines in horizontal sections, at the surface, 300 metres and 500 metres respectively.

These charts exhibit, in the main, the same peculiarities in distribution of temperature and salinity as the sections.

A particularly noticeable feature in the view given by the charts is in the fact that the isotherms and isohalines, especially in the intermediate depths between Section III and Section IV, run for the most part transversely to the direction of the channel. This is due to the fact that the water from the Norwegian Sea is very prominent in the north-eastern part of the channel, whereas the south-eastern portion is dominated by the Atlantic water.

This again arises out of the currents present in the channel, which we shall deal with later on, comparing them with the course of the isotherms and isohalines shown in the charts.

2. Mixing of the Water Layers.

As mentioned in the previous section, the position of the isotherms and isohalines in the areas where depths are less than 200 m shows that a great deal of mixing takes place between the water layers.

We have taken the difference Δt between temperature at 50 and 100 metres' depth and the difference Δs between salinity at the same depths, as an indicator of the strength of the mixing.

In fig. 25 on the left of the points showing position of the stations, the differences of temperature are noted in hundredths of a degree, and on the right of those points, the differences of salinity in hundredths pro mille.

Curves are drawn in the figure enclosing the areas within which the mentioned differences attain their maximum and minimum respectively. Areas where Δt is less than $0{,}1^0$ are shaded. In addition, the depth curves are shown for 100, 200 and 600 metres.

It will be noticed that the mentioned differences are very nearly 0, in the case of an area near the Faroes, an area near the Orkney-Shetlands and an area situated in the vicinity of the 600 metre curve on the north-western side of the channel.

In between these minimum areas we find maximum areas, where the differences attain very considerable values, varying also very considerably from one place to another.

The cause of this must undoubtedly lie in a difference in the intensity of mixing between the layers in one area as compared with that in another.

In the minimum areas, the mixing is very pronounced, partly owing to the water moving backward and forward over the shallower parts, and partly owing to the eddy movements accompanying the strong currents found on the south-eastern edge of the shelf, and in the central minimum area.

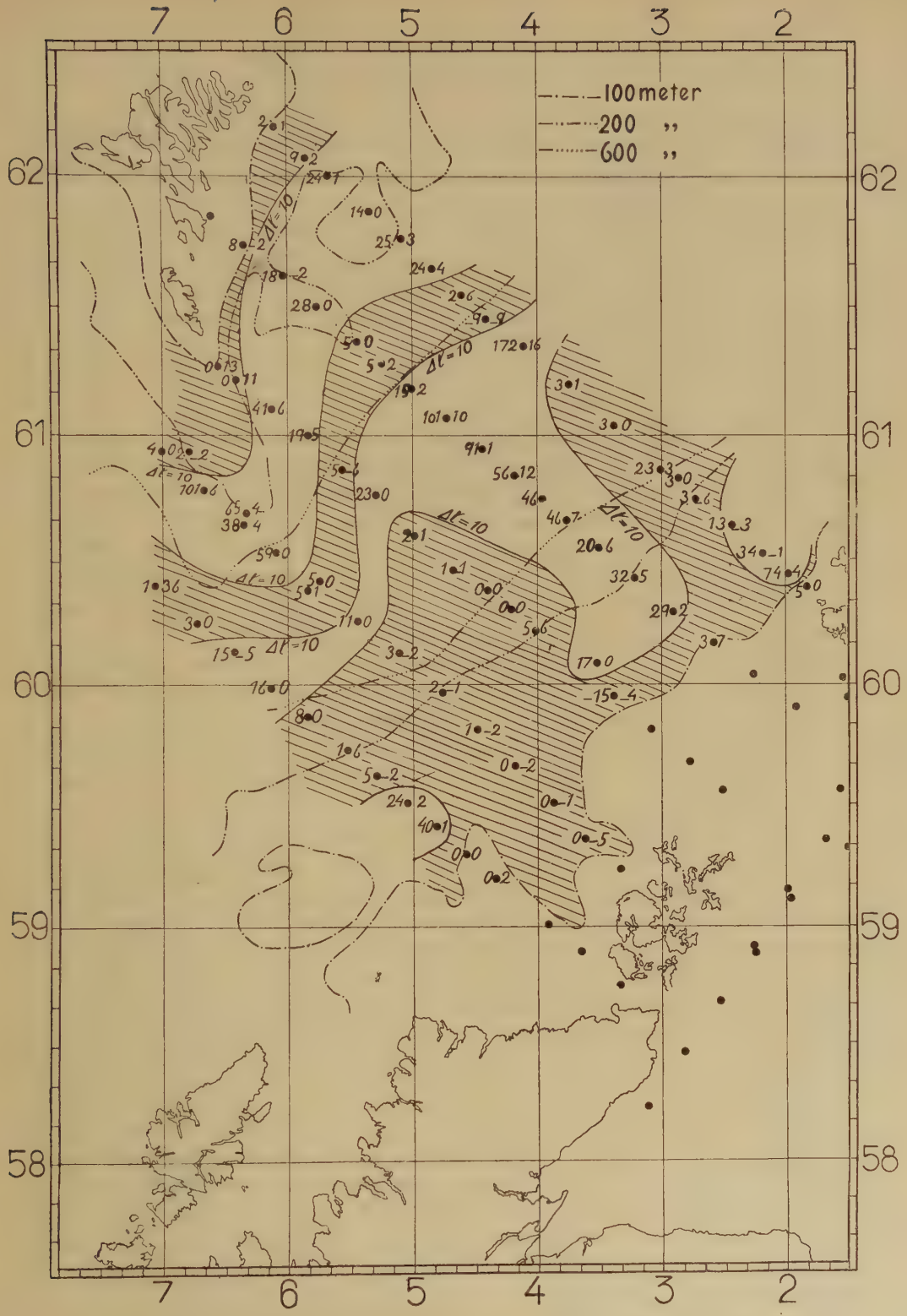


Fig. 25. Showing difference in temperature and salinity between 50 and 100 meter. The figure to the left of each station indicate $\triangle t$, the figure to the right indicate $\triangle s$ (units. 0.01° and 0.01 ‰).

The peculiar outline of the minimum area in the south-eastern portion of the channel is doubtless due to the fact that the current along Section IV carries the water in a south-easterly direction, the cold under-layer being thereby also carried up upon the shelf.

A clear general view showing which water masses penetrate into the Faroe-Shetland Channel from without, and what mixing takes place between them, may be obtained from a T-S diagram as shown in fig. 26. Here, the temperature and salinity in the different parts of the Faroe-Shetland Channel are set out as follows:

1) Water in the channel outside the 300 m limit to a depth of 300 m is marked •.

2) Water on the Faroe-Shelf (reckoned to a depth of 300 m) is marked ○.

3) Water from depths beyond 300 m is marked +.

It will be seen from the figure that points marked • lie for the most part grouped in the upper right-hand corner of the figure, which agrees with the fact that the water masses down to 300 metres depth outside the 300 metre line consist mainly of Atlantic water. A rectangle drawn in the figure encloses the points indicating occurrence in the channel of pure Atlantic water with salinity from 35.30 ‰ to 35.40 ‰ and temperature from 8° to 9°.

Similarly, it will be seen that points marked + lie mainly grouped in the lower left-hand corner of the figure which agrees with the fact that the bottom water in the Faroe-Shetland Channel is chiefly derived from the under layer in the Norwegian Sea. A rectangle drawn in the figure encloses points representing unmixed Norwegian Sea water, with salinity from 34.90 ‰ to 34.94 ‰ and temperatures from —1.3° to 0°.

Let us now imagine a certain quantity of Atlantic water, with temperature and salinity represented by the central point of the rectangle in fig. 26 enclosing the area of Atlantic water, and a certain quantity of Norwegian Sea water with temperature and salinity represented by the central point of the rectangle enclosing the area of bottom water from the Norwegian Sea. If these two water masses be mixed together, no interchange of heat with the atmosphere taking place during or after mixing, they should then, disregarding the proportion in which they are mixed, have a temperature and salinity represented in the figure by a point approximating very closely to the straight line joining the centres of the two rectangles.

On glancing at fig. 26 we now perceive that the points marked off there do not group themselves about any such line, and as we can, in respect of most of the water masses, regard any interchange of heat with the atmosphere as negligible, we may conclude that the water present in the Faroe-Shetland Channel and not being either unadulterated Atlantic or unadulterated bottom water from the Norwegian Sea, generally can not have been formed by a direct mixing of these two.

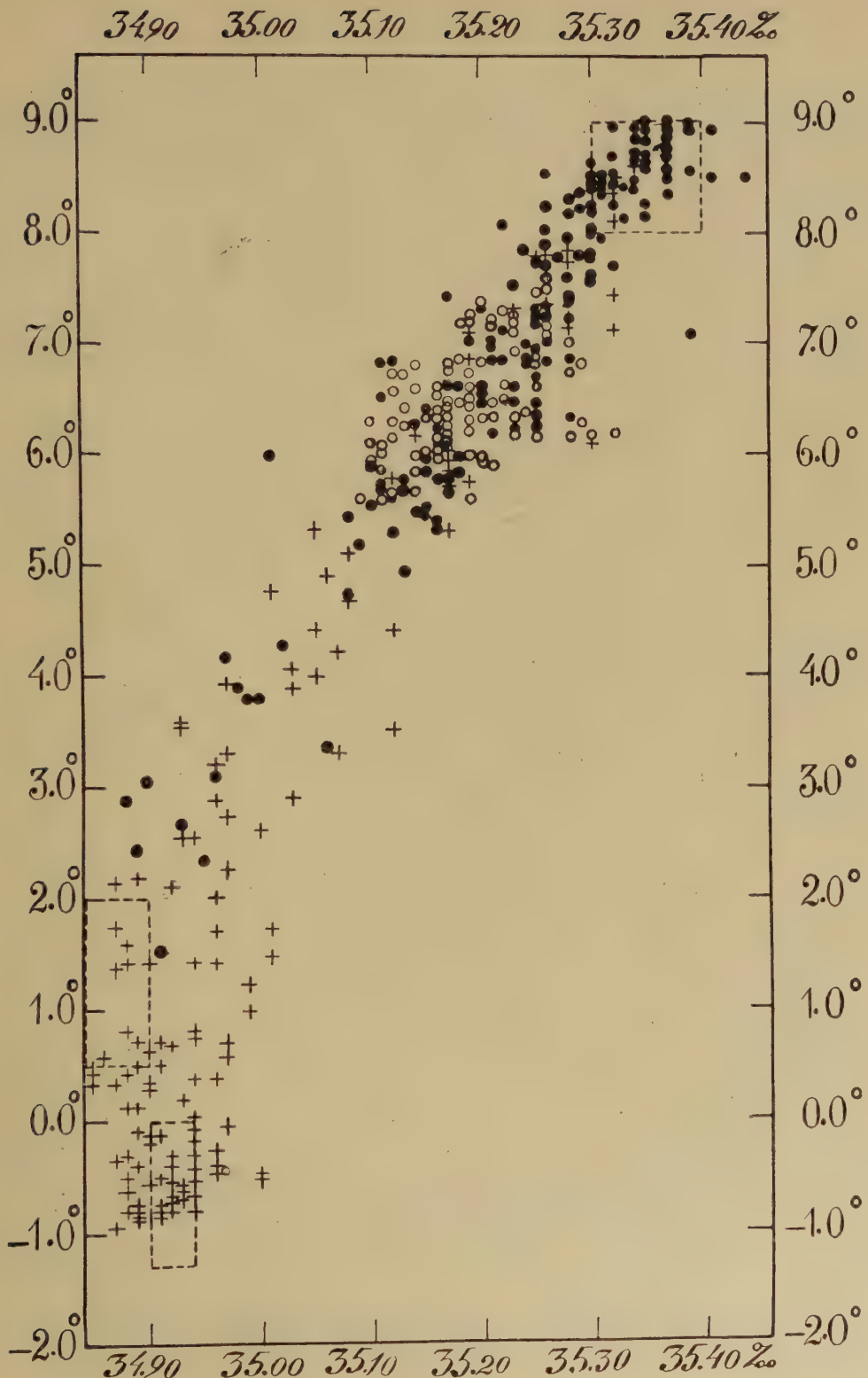


Fig. 26.

The points in the figure group themselves fairly systematically about a broken line, the upper portion af which joins the centre of the rectangle enclosing the area of Atlantic water with the centre of a rectangle drawn on the left of the figure, enclosing the area of water of salinity from 34.85 ‰ to 34.90 ‰ and temperature from 0.5° to 2.0°.

According to HELLAND-HANSEN and NANSEN[1]) water of these salinities and temperatures is found in the under layer in a depth of 300—400 metres of the East-Icelandic Arctic Current, which moves southward along the Iceland-Faroe ridge. We may therefore assume that it is water from this current which, after mixing with the Atlantic water, constitutes an essential part of the intermediate layers in the Faroe-Shetland Channel.

This applies also to the water on the Faroe Shelf on fig. 26 marked ○, where, however, the Atlantic water constitutes the main portion. The points denoting temperature and salinity of the water on the Faroe Shelf lie fairly closely grouped in the figure, which is naturally accounted for by the high degree of mixing which takes place here. Possibly, the interchange of heat between the surface water and the atmosphere may account for these points not lying still more closely assembled.

Finally, we see from fig. 26 that the lower portion of the broken line round which the points are grouped is very nearly vertical.

In agreement with this, we may assume that the lower intermediate layers in the Faroe-Shetland Channel are formed by mixing of the bottom water, partly with water from the East-Icelandic Arctic Current, and partly with mixed water from this and the Atlantic together.

Assuming, as we have done here, that water from the East-Icelandic Arctic Current, as well as from the Atlantic and bottom water from the Norwegian Sea, contributes to the formation of the water masses in the Faroe-Shetland Channel, we should also consider whether possibly other water masses of low salinity might not be responsible for the fact that the points marked off in fig. 26 group themselves systematically apart from the straight line representing mixed water formed directly from the Atlantic and Norwegian Sea.

Possible factors in this connection would be: coastal water from the northern coast of the British Isles, and water from the deep west of the Wyville-Thomson Ridge.

The coastal water in question, however, has a salinity of abt. 34.50 ‰ and temperature abt. 6.8°; and there are no points in fig. 26 which could indicate mixed water in which this coastal water formed an essential ingredient.

Finally, water west of the Wyville Thomson Ridge, of salinity below 35.00 ‰ is only found at depths from 1300—1800 metres and it may therefore be regarded

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[1]) Report on Norwegian Fishery and Marine Investigations Vol. II. No 2. Helland-Hansen and Nansen: The Norwegian Sea. Kristiania 1909. p. 293.

as out of the question that this could be carried by the current into the Faroe-Shetland Channel across the Ridge, where the greatest depth is 550 m.

The mode of procedure here employed in investigating the nature of water masses in a given area of sea has also been employed, as far as possible, in the case of entrance to the North Sea.

As later mentioned (p. 66) we assume that the water flowing into the North Sea from the Atlantic between the Orkneys and the Shetlands, comes from the north without being mixed to any essential degree with coast water from the Scottish shores. This assumption also proved to be correct by the investigation made, but since it is possible that the water may have been cooled — a matter of 1 or 2 degrees, — in the course of its movement in to the North Sea, and such cooling would render the proof of our assumption illusory, we cannot venture to regard it as decisive. The investigation showed that the water flowing into the North Sea between Scotland and the Orkneys consists of coastal water.

3. Solenoid Currents in the Faroe-Shetland Channel.

In order to investigate the fields of force produced by distribution of temperature and salinity in the area of the Faroe-Shetland Channel here considered, we have made use of the tables drawn up by Bjerknes[1]) and calculated, for the different stations, the depths in dynamic metres for the isobar surfaces 100, 200,···800 decibars.

From the depths thus ascertained, we have drawn topographical charts for the isobar surfaces in question. The charts are shown on a reduced scale in figs. 27 and 28, p. 54 and 55.

As previous investigations in the Faroe-Shetland Channel have shown, internal waves of over 100 metres in height may occur in this water[2]).

Observations, where repeated at the same stations, show no indication of any such internal waves; the repetitions were, however, so few in number (see p. 42) that they afford no proof that such did not exist at the time of the cruise.

If any internal waves were present during the course of the investigations in May 1924, it would dislocate to some extent the general view of temperature and salinity afforded by the observations. And a corresponding dislocation would be communicated to the charts showing depth of the isobar surfaces, which are based on these temperature and salinity values, as well as to the current charts subsequently drawn (p. 67 ff.).

From what we know of the waves and their magnitude, however, they would not to any essential degree alter the picture of current conditions obtained when they are disregarded.

[1]) V. Bjerknes: Dynamic Meteorology and Hydrography. Washington 1910.

[2]) See for inst. Martin Knudsen: Medd. fra Kom. for Havunders. Hydrografi Bd. II. Nr. 1. Fridtjof Nansen: Internat. Revue der gesamten Hydrobiologie und Hydrographie 1913.

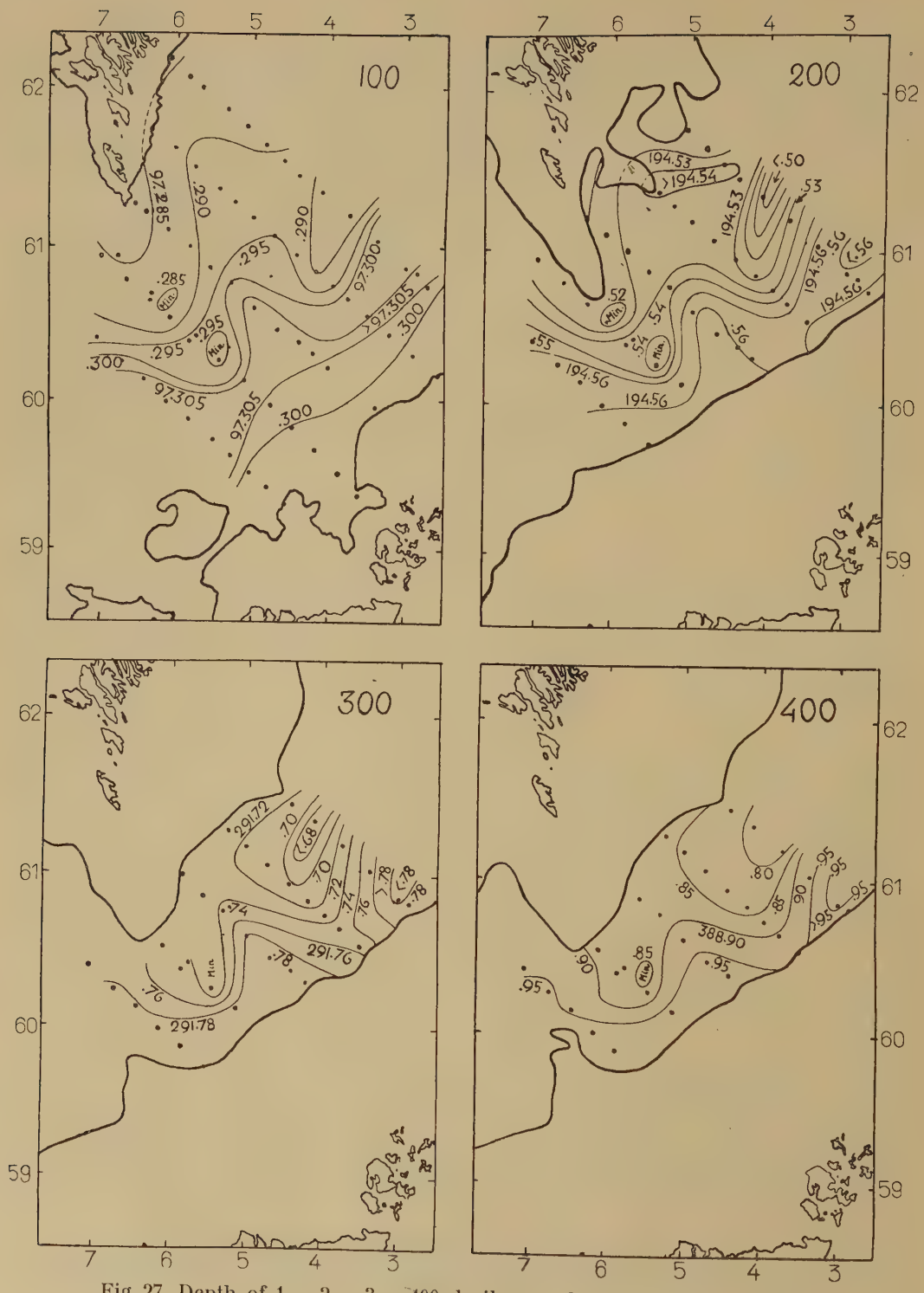

Fig. 27. Depth of 1—, 2—, 3—, 400 decibar surfaces beneath sea surface.

Fig. 28. Depth of 5—, 6—, 7—, 800 decibar surfaces beneath sea surface.

It will be seen that the isobars noted in the charts have more or less the same course at the different depths. It is characteristic, for instance, that we find, in the north-eastern and south-western parts of the channel, minima for the depth of the different isobar surfaces, and that the direction of the isobars in the central portion of the channel runs, in part, transversely to the course of the channel itself. The isobar surfaces lie deepest in the south-eastern portion of the area considered.

On comparing the course of the isobars for the different depths, however, it will be noticed that their directions differ somewhat as between surface and deeper down.

As we know, the direction of isobars, and the distances between them, in charts such as those in figs. 27 and 28, afford a means of determining the difference between currents produced by the solenoid field at the depth of the isobar surface in question and at the surface. If the isobars be so drawn that two successive isobars exhibit an increase in the depth of the isobar surface amounting to h dynamic centimetres, the distance between the isobars being l nautical miles, then the current difference in question, v, expressed in cm/seconds, will be determined by $v = 37.1 \cdot \frac{h}{l \sin \varphi}$

where φ is the latitude of the locality.

In the present instance, we can with sufficient approximation take $\varphi = 60^0$, and we then obtain: $v = 43 \cdot \frac{h}{l}$.

Reckoning from the current at the surface as zero, we can then, by means of the expression above noted, determine the currents at the different isobar surfaces, approximately situated at 100, 200···800 metres' depth.

The direction of the current is indicated by that of the isobars, the current flowing along these, so that the maximum depth of the isobar surface lies on the left of the current.

We thus obtain, from the charts in figs. 27 and 28, a view of the fields of force acting in the area considered, and also of the current conditions at the various depths, with the surface current as zero; the value of these charts is however, essentially reduced by the fact that the actual surface current is unknown.

It is better, then, to follow the mode of procedure often employed, calculating the currents at the various depths from the current at the bottom as zero, since the current at the bottom, at any rate in the deepest parts of the area, may be assumed to be weak in comparison with those of the upper water layers.

We have therefore calculated the topography of the sea surface itself from the assumption that the current at the bottom is zero. The result of these calculations is shown in fig. 30, p. 61, where the figures noted at the different stations indicate the height, in dynamic centimetres, of the sea surface above

the sea surface at a certain selected station, viz. S. 6.19, in the north-eastern part of the area investigated.

From the chart fig. 30 then, we can again find the difference between the current at the surface and that at the bottom; or, taking the latter as zero, find the current at the surface itself.

Finally, having once ascertained the current at the surface, it is easy to find the current at other depths.

With regard to the chart in fig. 30, it should be pointed out that certain curves based on figures directly obtained from the observations have been smoothed to some extent, and the chart itself is thus to a higher degree than the charts in figs. 27 and 28 subjected to hypothetical wievs.

The difficulty in drawing up chart fig. 30 lay mainly in the fact that we had to determine the difference in height of the sea surface for stations of different depth. Somewhat arbitrary treatment is here inevitable, especially when the two stations used for determining the difference lie so widely apart in point of depth as abt. 150 m and abt. 500 m as was the case with stations on the slope towards the deeper portions of the channel.

It would have been highly desirable, in such parts, to have had observations available from an intermediate station, or several such.

We will now briefly describe the mode of procedure employed in drawing up the chart fig. 30 giving the form of the sea surface.

Firstly, the difference in height for the sea surface between pairs of adjacent stations was determined, the stations being paired in different ways, but as the stations paired generally differed in point of depth, we cannot assume a difference of pressure = 0 in the potential surface cutting the bottom at the station of lesser depth. We have therefore, in determining the difference in height of sea surface between two paired stations, employed a method whereby the specific volume of the sea water below the potential surface in question is taken into consideration, at any rate to some degree.

In fig. 29, let the two lines A_1A_2 and $B_1B_2B_4$ represent the station verticals. A_1B_1 is the sea surface, A_2B_4 the bottom.

A_2B_2 represent an isobar surface, the depth of which below the sea surface for the two stations is imagined as calculated to a and b dynamic metres respectively. Reckoning from the surface, the depth of the isobar surfaces from A_2 to B_2 will then increase by $b—a$. If now the pressure in a potential surface at approximately the same depth as the isobar surface A_2B_2 was uniform throughout, then the sea surface at B_1 would be $b - a$ higher than at A_1 but owing to the differences in specific volume in the area $A_2B_2B_4$ we cannot take it for granted that the uniform pressure assumed in the mentioned potential surface implies uniform pressure »at bottom«. We will therefore add a correction to the difference of height, $b—a$, for the sea surface at A_2 and B_2.

In fig. 29 we will indicate the distance between the two stations A_1 and B_1 by L nautical miles, and the difference in depth of the stations by z.

The line $M_1M_2M_3M_4$ indicates a vertical at any given place in the section between the two stations. The distance A_1M_1 is denoted by x. Equidistant on either side of the line M_1M_4 we place the two station verticals $A'_1A'_2A'_4$ and $B'_1B'_2B'_3B'_4$ the distance between them being l nautical miles.

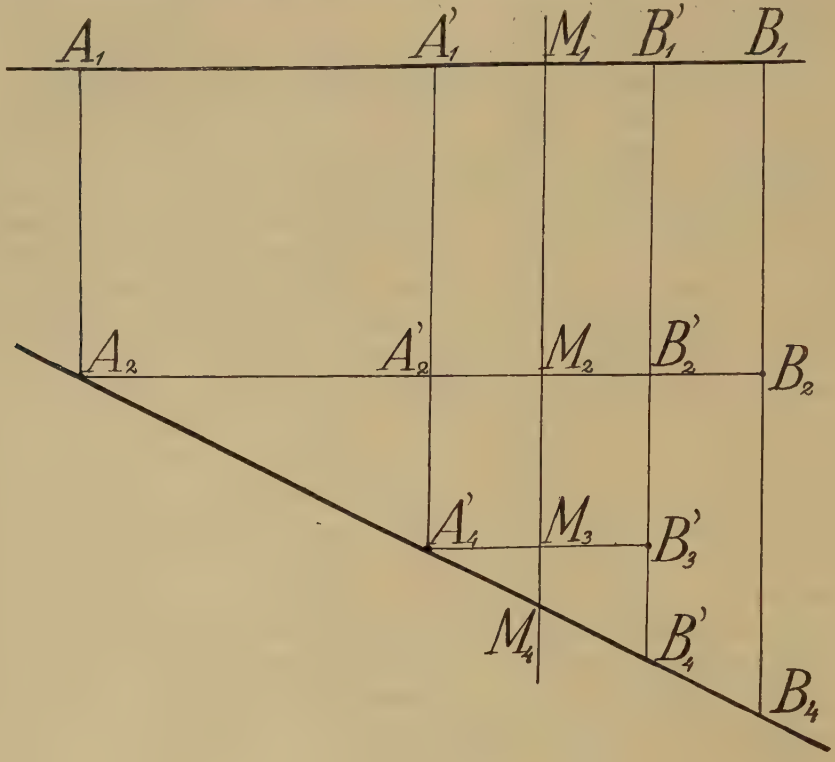

Fig. 29.

The vertical $A'_1A'_2A'_4$ touches the bottom at A'_4 and through this point is drawn an isobar surface intersecting the vertical $B'_1B'_2B'_3B'_4$ at the point B'_3. Our object is now first to determine the difference between the portions of the lines represented by $B'_2B'_3$ and $A'_2A'_4$.

We will call the specific volume of the water at the different points A_2, A'_2 etc., V, with the notation of the point as index, and assume that the specific volume of the water varies lineally in all directions within the area $A_2B_2B_4$, that the bottom curve $A_2A'_4M_4B'_4B_4$ is a straight line, and that we can, by interpolating to values of the specific volume within the area considered, regard the lines of intersection of the isobar surfaces with the section as parallel straight lines. We then obtain:

$$V_{A'_2} = V_{A_2}\left(1 - \frac{x - \frac{l}{2}}{L}\right) + V_{B_2}\cdot\frac{x - \frac{l}{2}}{L},$$

$$V_{A'_4} = V_{A_2}\left(1 - \frac{x - \frac{l}{2}}{L}\right) + V_{B_4}\cdot\frac{x - \frac{l}{2}}{L},$$

$$V_{B'_2} = V_{A_2}\left(1 - \frac{x + \frac{l}{2}}{L}\right) + V_{B_2}\cdot\frac{x + \frac{l}{2}}{L},$$

$$V_{B'_3} = V_{A_2}\left(1 - \frac{x + \frac{l}{2}}{L}\right) + V_{B_2}\cdot\frac{l}{L} + V_{B_4}\cdot\frac{x - \frac{l}{2}}{L}.$$

If the mean values of the specific volumes for the water columns $A'_2A'_4$ and $B'_2B'_3$, be denoted by $V_{A'_2A'_4}$ and $V_{B'_2B'_3}$ respectively, we then have:

$$V_{A'_2A'_4} = V_{A_2}\left(1 - \frac{x - \frac{l}{2}}{L}\right) + \frac{V_{B_2}}{2}\cdot\frac{x - \frac{l}{2}}{L} + \frac{V_{B_4}}{2}\cdot\frac{x - \frac{l}{2}}{L},$$

and

$$V_{B'_2B'_3} = V_{A_2}\left(1 - \frac{x + \frac{l}{2}}{L}\right) + \frac{V_{B_2}}{2}\cdot\frac{x + \frac{3}{2}l}{L} + \frac{V_{B_4}}{2}\cdot\frac{x - \frac{l}{2}}{L}.$$

The difference $V_{B'_2B'_3 - A'_2A'_4}$ in the mean values of the specific volumes in the two water columns $B'_2B'_3$ and $A'_2A'_4$ will then be:

$$V_{B'_2B'_3 - A'_2A'_4} = \frac{l}{L}\cdot(V_{B_2} - V_{A_2}).$$

We can now let l be so small a value, that we can disregard the distance M_3M_4 and write

$$M_2M_3 = z\cdot\frac{x}{L}.$$

The difference f between the two columns $B'_2B'_3$ and $A'_2A'_4$ can then be expressed by:

$$f = z\cdot\frac{x}{L}\cdot\frac{l}{L}(V_{B_2} - V_{A_2}).$$

Assuming now that the pressure in a potential surface situated approximately at the same depth as the isobar surface $A'_4B'_3$ is uniform throughout, B'_2 and A'_2 must have a difference of height which will be

$$z\cdot\frac{x}{L^2}\cdot l\cdot(V_{B_2} - V_{A_2}).$$

Consequently, reckoning from A_2, the height of the surface A_2B_2 in relation to a potential surface per nautical mile for any arbitrary value of x will increase by $z \cdot \frac{x}{L^2}(V_{B_2} - V_{A_2})$ and from this again it follows that B_2 must lie a certain number, c, of dynamic metres higher than A_2, c being determined by:

$$c = \int_0^L z \cdot \frac{x}{L^2}(V_{B_2} - V_{A_2}) \cdot dx,$$

that is

$$c = \frac{z}{2} \cdot (V_{B_2} - V_{A_2}).$$

Adding this correction to the difference in height $b—a$ previously found for A_1 and B_1, we find that the the sea surface at B_1 must be $b - a + c$ higher than at A_1, c having the value above noted.

For stations of like depth, this expression will be reduced to $b—a$, but where there is any difference in the depth, we must add to $b—a$ half the product of the difference in the depth, and the difference between specific volume at bottom at the station with the lesser depth, and the specific volume at the other station at the same depth.

By means of the formula thus obtained, we have calculated the difference in height between adjacent stations, taken in pairs. In certain parts of the area, where the form of the surface was awkward to determine, this was done in as many different ways as possible, and the differences in height so found between the stations set out on a chart like fig. 30 on a larger scale. It was then possible, by graphical adjustment, to draw smoothed curves indicating, like those in fig. 30 the topography of the sea surface.

In smoothing the curves, it was necessary throughout to keep the sum of differences in height along a closed curve as far as possible = 0. This condition was more easily fulfilled in the case of the deeper parts when the term $\frac{z}{2}(V_{B_2} - V_{A_2})$ was included, than when this was disregarded. Generally speaking, the term was of but slight numerical value.

As already mentioned, it was difficult to determine the inclination of the sea surface above the slopes of the channel between abt. 150 and 500 metres, especially on the south-eastern side. The difficulties were just apparent in the case of stations at the mentioned depths thereby that it was impossible to keep the sum of differences in height along a closed curve = 0. We therefore choiced to let the differences in height found in Section III on the south-eastern side of the channel take precedence of the remaining difference in height for the area where depths were between 150 and 500 metres.

The reason for preferring the differences in height found in Section III to

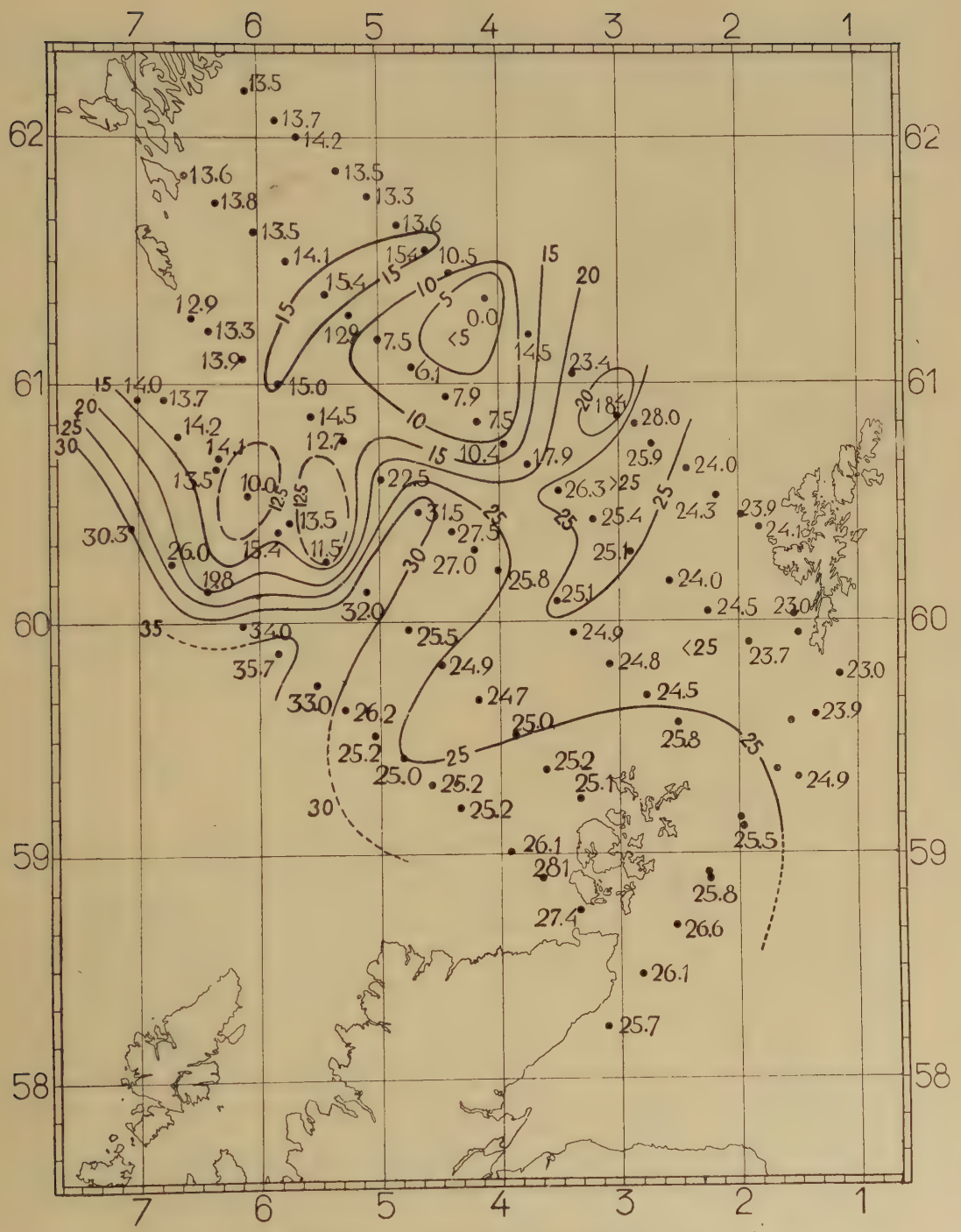

Fig. 30. Topography of the sea surface (dynamic cm).

others was firstly, that the agreement between smoothed and directly calculated differences was thus best on the whole, and also that the greatest difference in height between two successive stations on the slope towards the deeper parts is less in Section III than in the other sections; and finally, that owing to the direction of the current, which runs transversely to the longitudinal course of the channel itself at the place where Section III cuts the south-eastern slope of the channel (see figs. 33—35) we should expect less difference in the specific volume of the water than in places where the current mainly follows the longitudinal direction of the channel.

By the method above indicated, then, we have drawn up the chart in fig. 30. At each of the stations noted in the chart we have indicated the height of the sea surface above the geoid surface, which goes through St. S 6.19 in the north-eastern portion of the area investigated.

The difference between the heights noted agreed as a rule with those calculated within a few millimetres, save where there was great difference in depth between the stations compared.

For stations on the south-eastern slope of the Faroe-Shetland Channel, on the other hand, some of the calculated differences had to be regarded as worthless. We found, for instance:

Stations.....	6.5→6.2	9.22→10.0	11.10→11.8	12.15→12.18	S6.1→S5.20
Depth in metres.....	420 130	510 140	360 165	590 305	784 460
Difference in height found, dynamic cm	—0.8	—0.7	—0.8	—0.8	5.8
Smoothed value for difference in height, dynamic cm	—6.8	—6.5	—1.2	8.4	9.6

For the reasons mentioned above, we will assume that the values found by smoothing answer to the actual conditions, whereas the direct determination of the difference in height is in several cases illusory. Some few instances of similar character to those here noted were also found on comparing the stations in the western corner of the area.

From the isobars drawn in fig. 30, as a rule for every fifth dyn. cm. it appears that in the north-eastern part of the channel there is a pronounced minimum about St. S 6.19 in Section V, at which station the position of the sea surface has been taken as representing zero.

In the south-western part of the channel, there is a pronounced maximum for height of sea surface about St. 6.7 in Section I. The sea surface at this point is abt. 35 cm higher than at St. S 6.19.

Having now determined the form of the sea surface itself, we can easily

Fig. 31. Topography of the 300 decibar surface (dynamic cm).

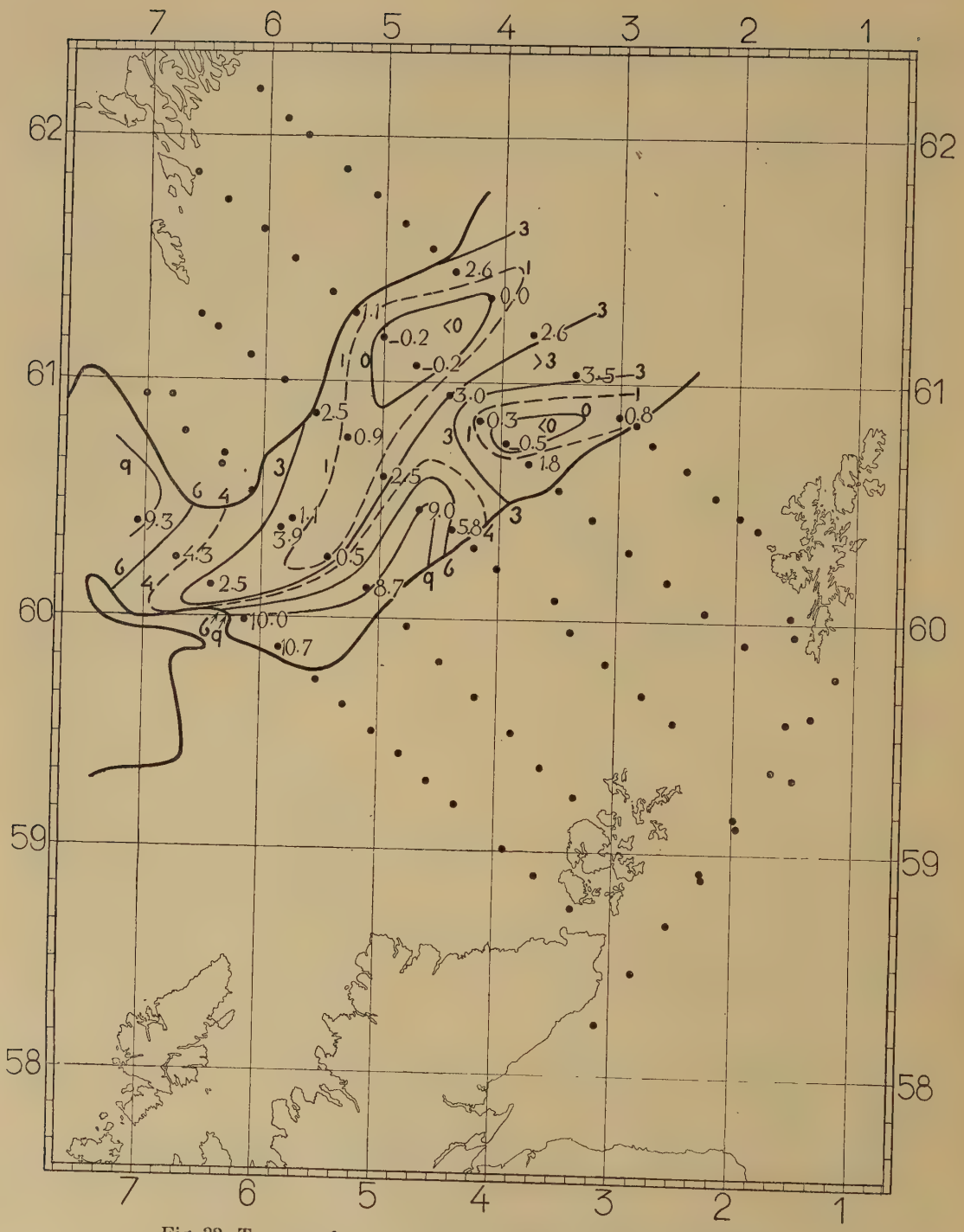

Fig. 32. Topography of the 500 decibar surface (dynamic cm).

find that of the isobar surfaces lying deeper down, as these are known in their relation to the sea surface. In figs. 31 and 32 we have indicated the form of the isobar surface for 300 decibars and 500 decibars, lying at abt. 300 and abt. 500 metres' depth respectively. Curves have been drawn for every third dyn. cm., for 500 decibars, as broken lines, for some others too.

It will be seen from the three charts that the course of the isobars in the three depths selected shows certain characteristic features common to all. We find for instance, that the isobars lie close to the southern slope of the channel, and turn off, at any rate to some extent, towards the south-east in the middle portion of the area. The position of the above mentioned maximum and minimum for height of the sea surface relative to the potential surface is also found again at 300 and 500 metres.

From the forms of isobar surfaces thus found, we can calculate the currents, by means of the formula given on p. 56, for 0, 300 and 500 metres.

In the case of the surface itself, we have noted, in the chart fig. 33, p. 67, the calculated current velocities in cm/sec. In the case of the stronger currents, we have rounded off the values to 10, 20, 30 etc. cm/sec., this approximation being here presumably in accordance with the degree of accuracy with which current velocity can be stated at the individial points. The lines, which are mainly drawn parallel to the isobars, are intended to denote the direction of current; they are, however, more or less estimated.

It will be seen from the chart that the water coming in from the northward has an average speed of $^1/_2$—$^2/_3$ knots. On the south-eastern slope of the channel, the current turns eastward, and moves, with a somewhat undulating course, at great velocity (up to 1 or 2 knots) north-eastward into the Norwegian Sea. A branch of the current turns off towards the south-east, and moves, likewise with an undulating course, in to the North Sea between the Orkneys and the Shetlands. The velocity of the water in this branch of the current is however but slight, abt. 2 cm/sec.

The current chart shows a cyclonic movement of the water in the eastern part of the channel, the southern portion consisting of the above-mentioned east-going current.

Consideration of the chart further shows that there are areas with eddy formation, and others where there is no current.

Fig. 34, p. 68 shows the current at 300 metres' depth in the same way as at the surface. It will be noticed that the movement of the water in the south-eastern portion of the channel is mainly the same at this depth as at the surface. In the north-western part of the channel on the other hand, there are currents with a south-westerly direction, which were not present at the surface throughout the whole course of the channel, but only on the north side of the cyclonic eddy in the eastern part of the area.

At 500 metres depth, as shown in fig. 35, p. 69, the appearance of the currents

in the south-eastern part of the channel is again the same as at the surface and 300 metres' depth. In the north-western part of the channel there is a current tending in a south-westerly direction of about the same velocity as at 300 metres, whereas the cyclonic movement in the eastern part of the channel at this depth is less pronounced.

The movement of the water at the entrance to the channel is also essentially different from what it was at the surface and at 300 metres. It flows north-eastward in the south-eastern portion, and south-west in the north-western part.

On comparing the current charts shown in figs. 33, 34 and 35 for surface, 300 metres and 500 metres depth with the charts previously given in figs. 22, 23 and 24, pp. 45, 46 and 47, showing course of the isotherms and isohalines for the same depths, it is easy to understand how the currents indicated on the charts come to carry the various kinds of water between which we have distinguished in the foregoing, into the Faroe-Shetland Channel. It will be seen that the direction of currents, isotherms and isohalines is generally the same.

From the upper layers west of the Faroes, and from the deeper ones south of the Faroe Bank, Atlantic water is carried in to the Channel, where it is mainly found in the south-eastern portion. From here again it flows out into the Norwegian Sea.

From the upper layers north-east of the line Faroe-Shetland, the Atlantic water, probably mixed to some extent with water from the East-Icelandic Arctic Current, is carried into the north-western part of the Channel, where it mixes with the water present in the Channel, and part is again transported out of the channel via the south-eastern area.

From depths of 300—500 metres north-east of the Faroe-Shetland line, water mainly derived from the East-Icelandic Arctic Current is carried into the channel. Together with the bottom water from the Norwegian Sea, which likewise comes mainly from the north-east, it keeps for the most part to the depths in the north-western part of the channel. Part of it possibly moves thence again over the Wyville Thomson Ridge down towards the depths of the Atlantic.

The occurrence of these water masses in the Faroe-Shetland Channel, and their mixing one with another, have already been referred to in the discussion of the sections (see p. 34 ff.) and mixing of the water (see p. 48 ff.).

According to the current chart in fig. 33, the water flowing between the Orkneys and the Shetlands into the North Sea, comes, as already mentioned, from the area west of the Faroes, this water, in the course of its passage through the channel, becoming mixed with the other water masses there found. Presuming the picture of the currents we have arrived at to be generally valid, which would have to be determined by future investigations, this feature is undoubtedly of interest. We have previously pointed out that the study of temperature and salinity in the water at the entrance to the North Sea suggested the Faroe-

Fig. 33. The currents at 0 m. The figures indicate the velocities in cm/sec.

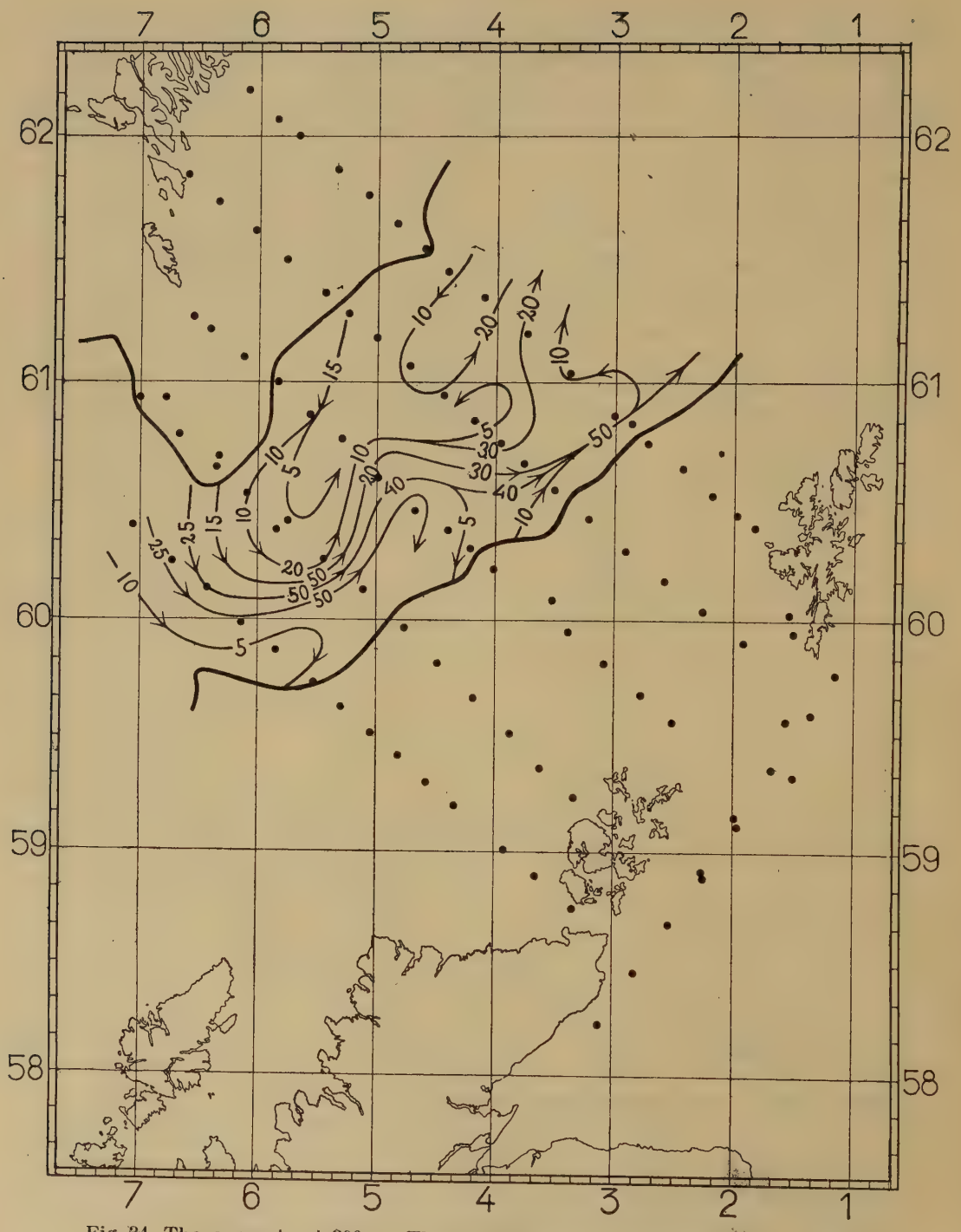

Fig. 34. The currents at 300 m. The figures indicate the velocities in cm/sec.

Fig. 35. The currents at 500 m. The figures indicate the velocities in cm/sec

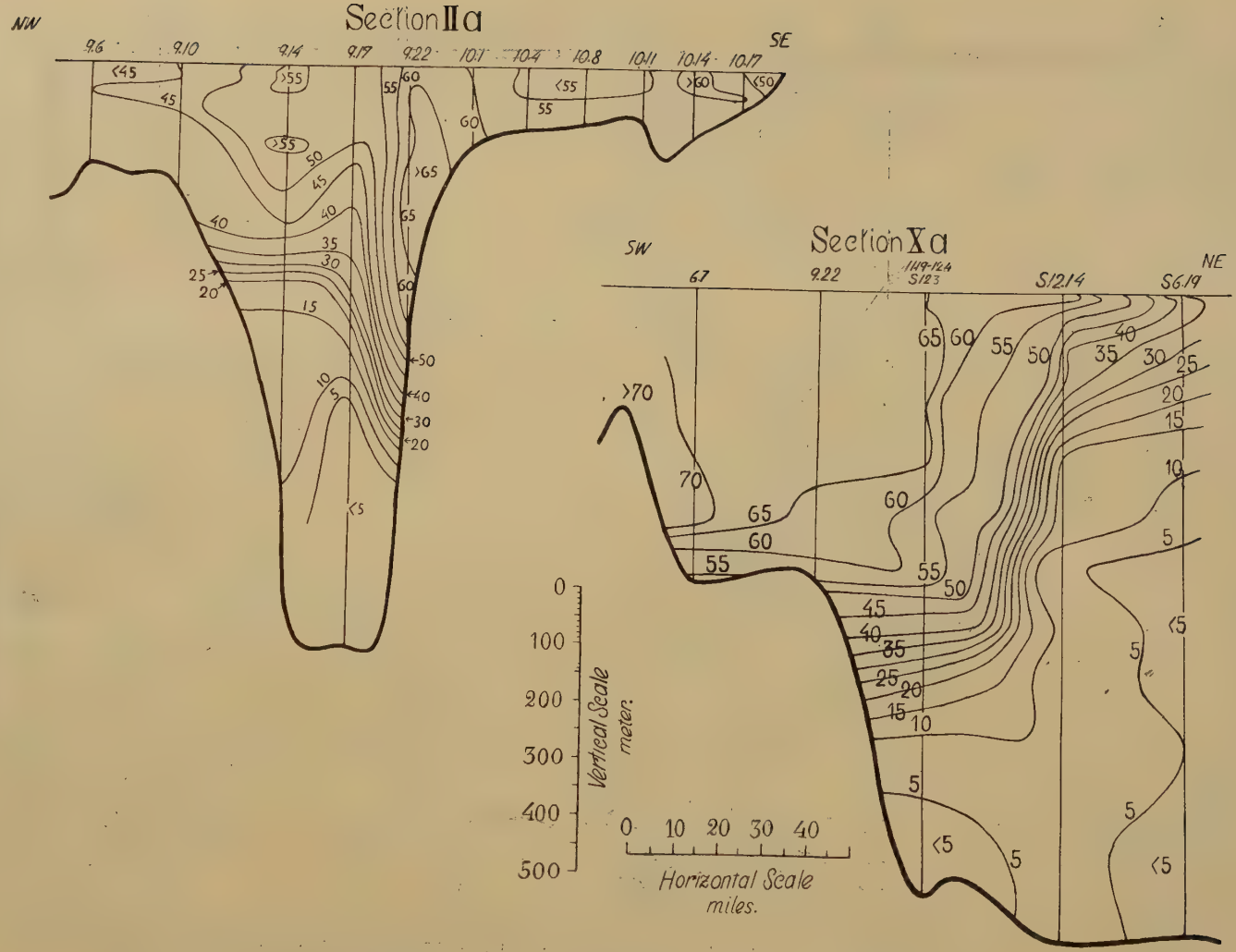

Fig. 36. Section II a and fig. 37. Section X a: Anomalies of specfic volumes in relation to water of 0° and 35 ‰ (unit: 10^{-5} m³/ton).

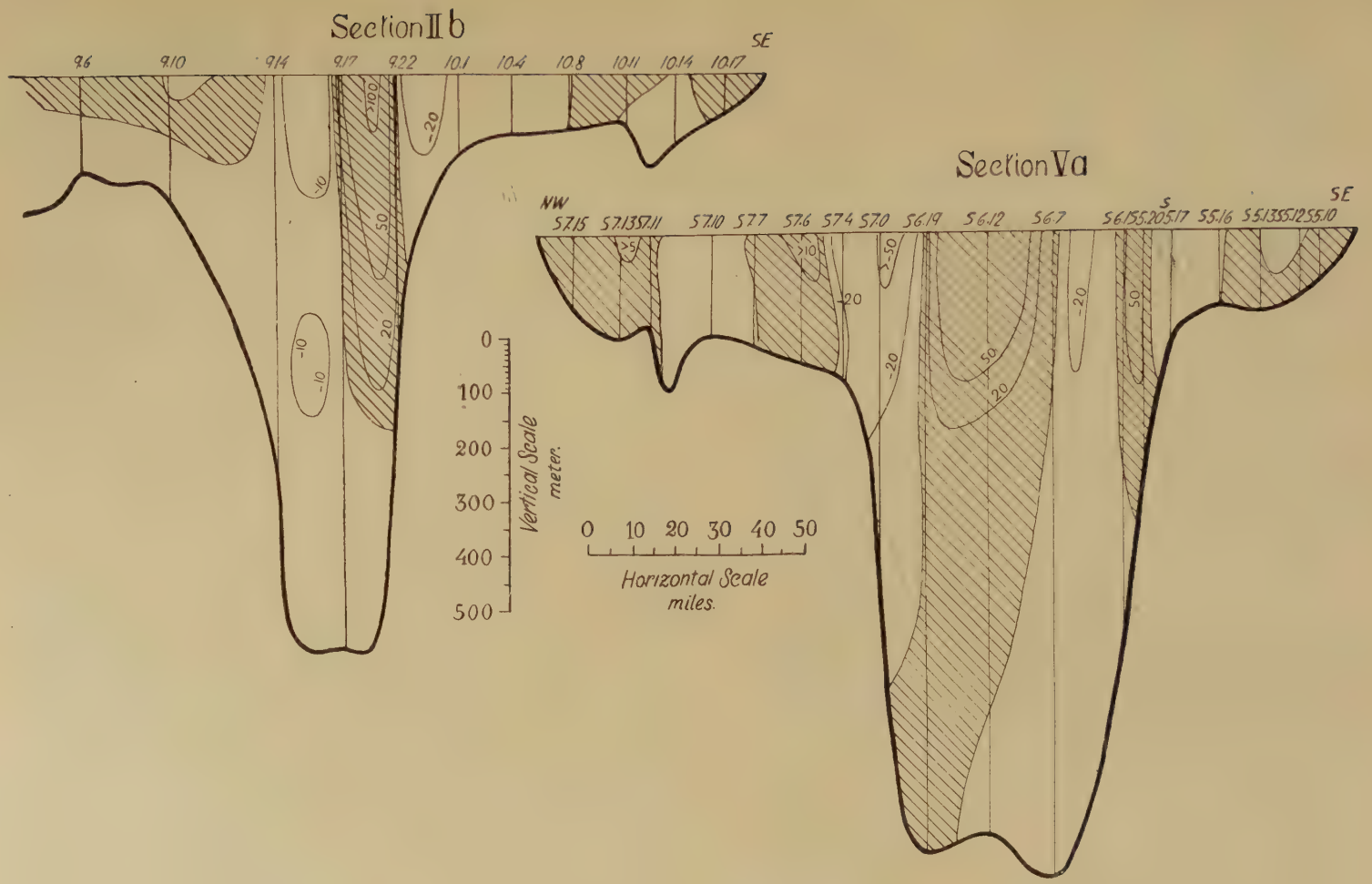

Fig. 38. Section II b and fig. 39. Section V a: Hatching indicate current running to NE. The figures indicate the velocities in cm/sec.

Shetland Channel as the source of origin of the inflowing water. Only between Scotland and the Orkneys do we find pronounced coastal water.

As a further illustration of the fields of force in the Faroe-Shetland Channel, we have drawn, in figs. 36 and 37, p. 70 curves for the anomalies of specific volumes in sections II and X (see fig. 8).

In conjunction with the isobars, which appear in the figures as horizontal

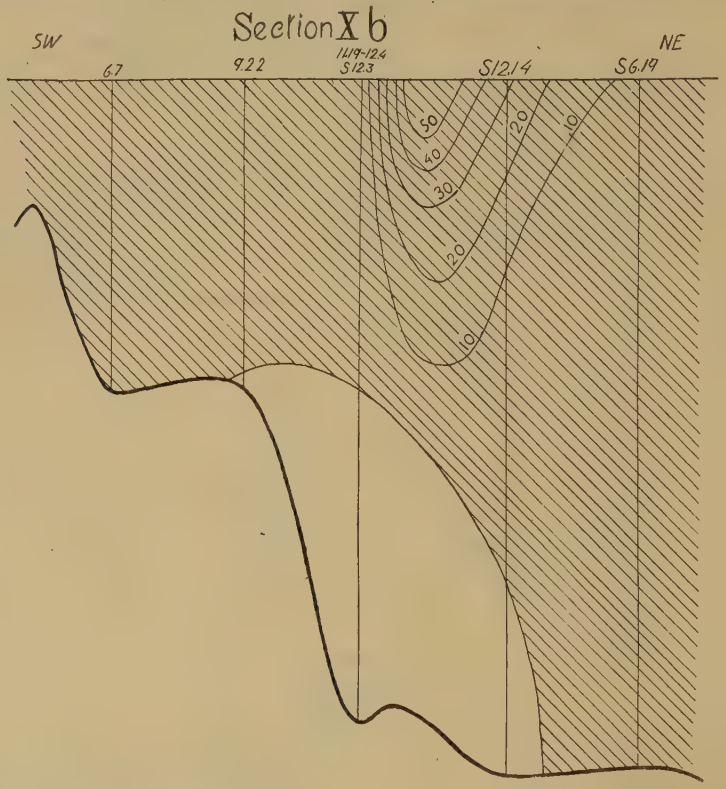

Fig. 40. Section X b. Hatching indicate current running to SE. The figures indicate the velocities in cm/sec. (Same scale as the preceeding figs. 36—39).

lines, we have in these figures pictures of the fields of force producing the solenoid currents at right angles to the sections in question.

Furthermore, in figs. 38, 39 and 40 we have shown the currents found at the different depths at right angles to sections II, V and X respectively (see fig. 8, p. 32), presuming the current at the surface to be as noted on the chart in fig. 33. The currents have been calculated from the formula given on p. 56, on the basis of the form of sea surface indicated in fig. 30, and the calculated depths of the isobar surfaces for the different stations. The curves have, however, been somewhat smoothed. The direction of current is indicated by hatching where the current at right angles to the section moves toward NE and SE respectively. The velocity is noted in cm/sec.

In addition to the currents noted in this section, due to the solenoid field, and always presumably present, in all essentials, in the form here indicated, the conditions of wind can of course give rise to currents which might at times very largely modify this state of things. It must be borne in mind, however, that this only takes place occasionally, at certain periods and in varying directions, so that the currents here considered may be assumed to be those essentially affecting the interchange of water.

Finally; it must be remembered that the currents found have been calculated from the bottom current as zero, and it is only at the greater depths that we can safely assume the bottom current to be actually 0.

B. Hydrographical Investigations in Iceland Waters.

1. Temperature and Salinity at different stations.

During the period from the 3rd to 17th of May, temperature observations were made in Iceland waters from the French vessel »Ville d'Ys«, commanded by Capitaine de Fregate Huau. The observations covered 16 stations in all.

Further, during the period from 1st June to 1st August, some 90 hydrographical stations were taken by the »Dana«, with observations of temperature and salinity.

The position of the stations is shown in fig. 9, p. 33. At each station date for the observation is noted.

It is seen that only very few of the stations lie more than 20 nautical miles from land, most, indeed, being lees than 10 nautical miles out. Nearly all the stations are situated on the shelf.

The observations from those of the »Dana« stations which lie in a line at right angles to the coast are taken together in sections J I—J IV shown in figs. 41—49, pp. 74 and 75; at the stations date and hourshot are indicated. The positions are as noted in the chart fig. 9, and as indicated in the table below, where also the times when the stations are taken are stated.

Section	J I	South of Reykjanes Peninsula	8—9 June
—	J II	West of Snæfellsnes	a) 8 June b) 1 July c) 15 July
—	J III	Near Cape Horn	a) 6 June b) 2 July c) 18 July
—	J IV	North of Eyjafjord	a) 5—6 June b) 19—20—21 July

The observations afford some information as to the alterations in temperature and salinity which have taken place during the months in question; this applies more especially to the series of observation repeated at exactly the same place.

We will then first of all consider the sections where repeated observations were made.

In the section J II west of Snæfellsnes, fig. 42—44, we find, nearest land, a water mass with salinity less than 35 ‰. This is coastal water, and moves, as we know, here towards the north.

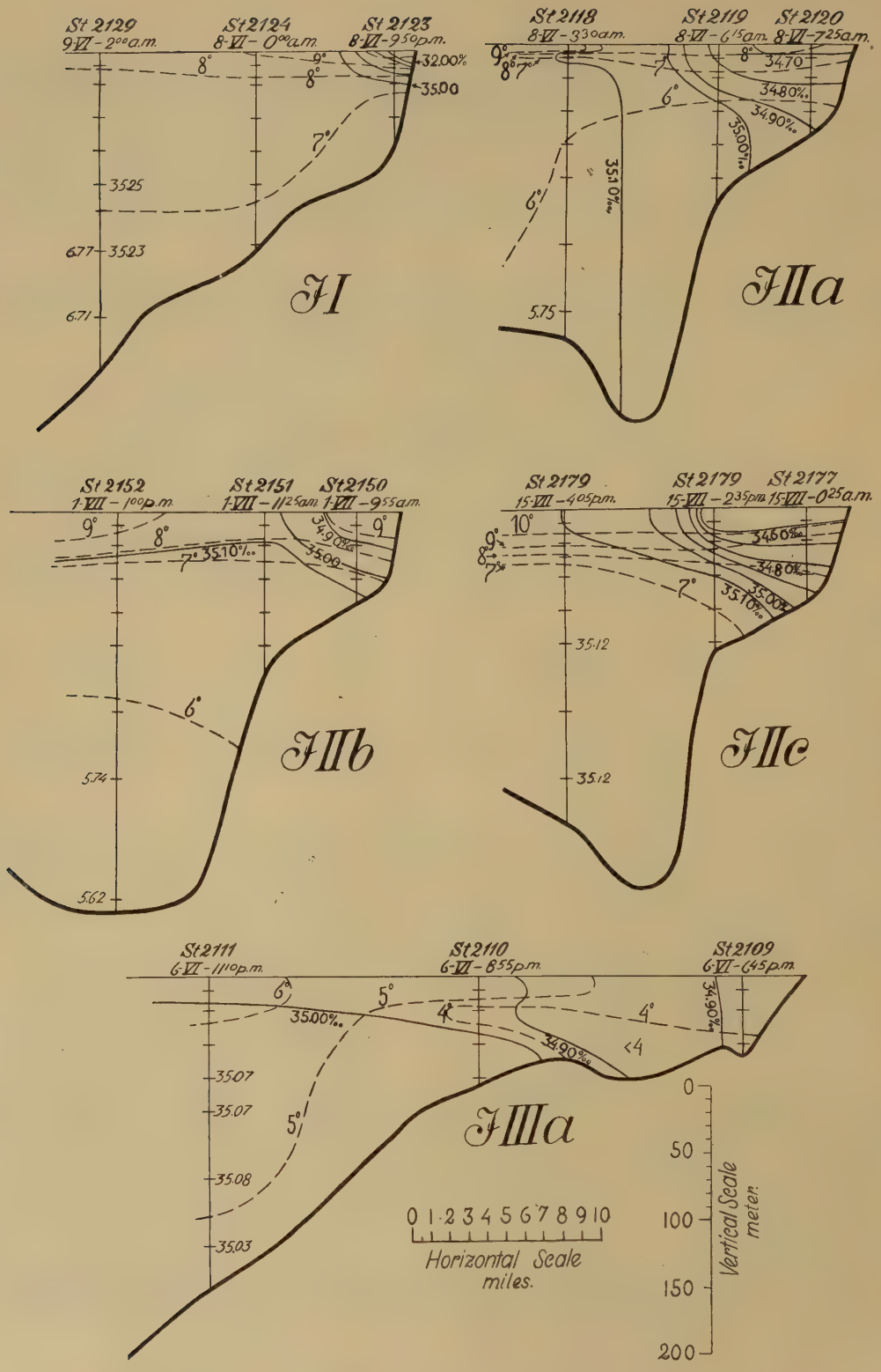

Fig. 41. Sect. J I. Fig. 42—44. Sect. J II a, b, c. Fig. 45. Sect. J III a.

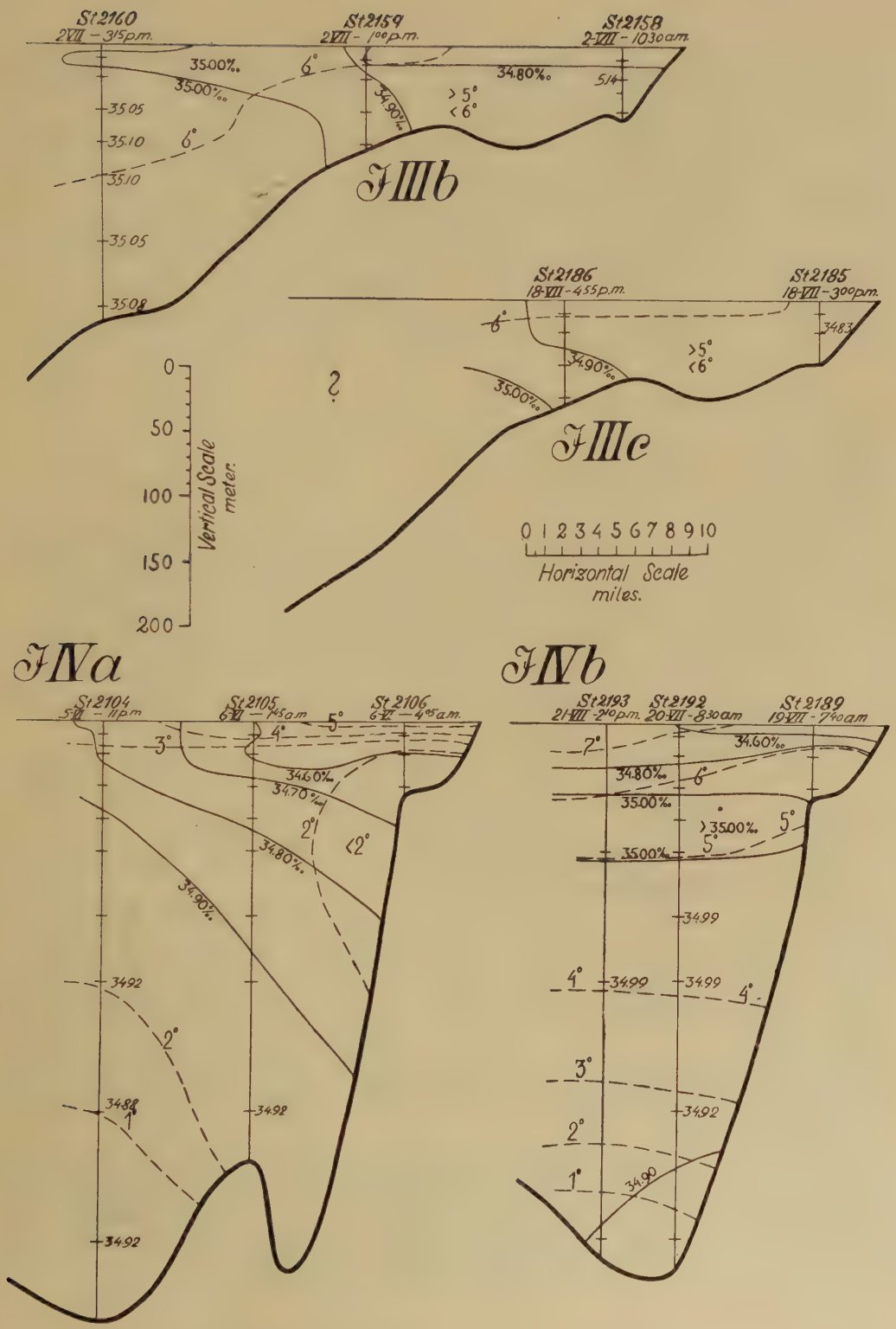

Fig. 46—47. Sect. J III b, c. Fig. 48—49. Sect. IV a, b.

The observations show that the thickness of the coastal layer varied considerably, with a minimum for the section on 1 July.

The variations may perhaps be due to the state of the wind.

The table below shows the direction and force of the wind at Reykjavik during the five days preceding the series of observations.

No. of days prior to taking observations.	Section taken 8 June		Section taken 1 July		Section taken 15 July	
	Wind		Wind		Wind	
	Direction	Force	Direction	Force	Direction	Force
5		0	NW	3	E	7
4	NW	2	N	5	E	6
3	E	4	E	5	S	4
2	E	3	N	7	NE	1
1	N	2	N	6	S	3

The minimum for thickness of the coastal water in the section taken 1 July must presumably be due to the strong north winds of the days immediately preceding as seen of the table, having checked the coastal current round Snæfellsnæs.

In the water with more than 35 ‰ it will be noted that the 35.10 ‰ curve for the two series of observations in July lies farther in over the shelf than in June. This agrees with the fact that the permanent station at Akranes, in Faxe Bay, which we shall consider later on, showed for the bottom water, maximum at the beginning of July.

In the water over 35 ‰ the temperature, save in a surface layer abt. 35 m. thick, was fairly constant from the beginning of June, when it was a little below 6°, to the middle of July, when it was a little over 6°.

In the surface layer already mentioned, and in the coastal water, the temperature rose during this period more than 1°.

In the section J III near Cape Horn, fig. 45—47, the salinity was, in contrast to the section at Snæfellsnes, on the whole uniform throughout in the three series a) b) and c).

As regards temperature, the observations showed on the 6th of June temperatures under 4° in the coastal water at depths between 20 and 75 m., higher temperatures being found both in the upper layer of the coastal water and in the water with over 35 ‰ salinity, which bounds the area of the coastal water on the north-west.

Between these series of observations, the temperature of the coastal water rose, and by the 2nd July, the temperature at 20—75 m. depth had reached nearly 6°. In the adjacent salter water the rise was far less pronounced, and the 2nd Juli we find here also 6°. The intermediate temperature minimum in the deeper layer of the coastal water had thus disappeared.

The section J IV at Eyjafjord, figs. 48—49, shows a great difference in temperature and salinity between the two series of observations.

On the 5th and 6th of July, 35 ‰ water was not found in the section, whereas on the 19—20—21 July it appeared as an intermediate layer from 50—60 m. depth to a little over 100 m.

An intermediate temperature maximum with abt. 3° found at St. 2104 (sect. J IV a, fig. 48) at 75 and 100 m. depth must be considered as due to an admixture of warmer water. This was perhaps present as an intermediate layer north of the section at the beginning of June.

The deeper water layers show, by their low temperatures in connection with low salinities, the effect of arctic water. This was most pronounced at St. 2104 at 300 m. depth.

The intermediate water layer with about 35 ‰ in the section J IV b from 19—20—21 July constitutes, as the relatively high temperatures and salinities show, a considerable portion of the deeper water layer down to 200 m. At the surface also, an admixture of warm, salt water is perhaps discernible. It is the saltest portions of the surface water which were heated most in the interval between the two series of observations, which is presumably due to admixture of water from the intermediate salt layer, which was already warm

Low temperatures — less than 2° — were in sect. J IV a found in an intermediate layer from abt. 20 to perhaps 200 m. depth. This water layer was similarly situated as the intermediate cold layer in the section near Cape Horn, and disappeared, likewise, between the two series of observations.

The remaining stations along the north coast of Iceland afford no information as to the extent of the alteration in distribution of water over 35 ‰ as shown in the section north of Eyjafjord.

A series of French stations are situated off the Vestra Horn. The rise in temperature outside the 200 metre limit during the period from 3—4 May, when they were taken, to 1 and 2 June, when observations were made here from the »Dana«, was but slight. In shallower water, on the 3—4 May, a temperature minimum at abt. 4° was found along the bottom, similarly as in the sections north of Iceland a temperature mimimum was found in the deeper parts of the coastal water. Owing to the heating to which the coastal water was subjected during this period, the temperature minimum had almost disappeared when the observations were made on the 1 and 2 June.

Apart from the information afforded as to variations in temperature and salinity, these observations in Iceland waters give some idea as to the occurrence of coastal water, Atlantic water and arctic water at this season. The view thus presented agrees with what is known from the observation of previous years.

Attention should perhaps be drawn to the very low salinities in the section J I south of Reykjanes Peninsula (fig. 41) (down to 32 ‰ and under). Such low values as these have not been observed west of Iceland, and the water masses must thus evidently have become greatly mixed on their passage round Reykjanes.

2. Temperature and Salinity at the permanent station at Akranes.

The observations were repeated 24 times during the period from $^{9}/_{6}$ 1924 to $^{17}/_{5}$ 1925.

These observations render it possible in the first place to determine the annual course of the temperature and salinity, and also to examine occasional alterations.

The observations made in 1924 were published in the »Bulletin Hydrographique« for 1924; those made in 1925 are shown in the table below.

m	$^{10}/_{2}$ 25		$^{6}/_{4}$ 25		$^{15}/_{4}$ 25		$^{17}/_{5}$ 25	
	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀	t°	S°/₀₀
0	2.91	34.47	3.12	34.83	3.70	34.60	6.06	34.47
5	.82	.49	.16	.83	.83	.60	.07	.45
10	.84	.47	.21	.85	.44	.63	.08	.47
15	.95	.47	.30	.87	.39	.65	.02	.52
25	3.18	.54	.50	.96	.30	.76	5.71	.65
35	.36	.60	.56	.99	.27	.78	.32	.79
50	.38	.63	.62	35.01	.30	.78	.20	.81

The annual course as shown by the observations when expressed in a smoothed graph is given in the diagram fig. 50 next side.

It should be noted that between the occurrence of the summer temperature maximum at the surface and at 50 m. depth, there is a displacement of the maximum of over a month, from the early days of August to first half September. The winter temperature minimum for the water column as a whole falls at the beginning of March, and, in accordance with the higher degree of mixing between the water layers during winter, we find only a slight displacement of the minimum for surface and bottom. From September to April, the difference in temperature between surface and bottom averages $^{1}/_{2}{}^{0}$ or less.

The salinity curves show a somewhat different course as to surface and bottom. Both show a minimum salinity at about the same time (in November) but the maximum salinity occurs at different times for surface and bottom.

At the bottom, we find a maximum salinity at the beginning of July, whereas at the surface, about the same time (abt. 1 July) there is a secondary minimum between a principal maximum in April and a secondary in August.

With regard to the November minimum, a displacement is observed from surface to bottom of about half a month, from early November at the surface to end November at the bottom.

In order to investigate the influence of force and direction of wind on varia-

tions in the salinity, the salinity observations from June and July 1924 have been set out graphically in fig. 51, p. 80, where also force and direction of wind at Reykjavik are noted. It will be seen that the distribution of salinity is to a great extent dependent on the force of the wind. We find a pronounced discon-

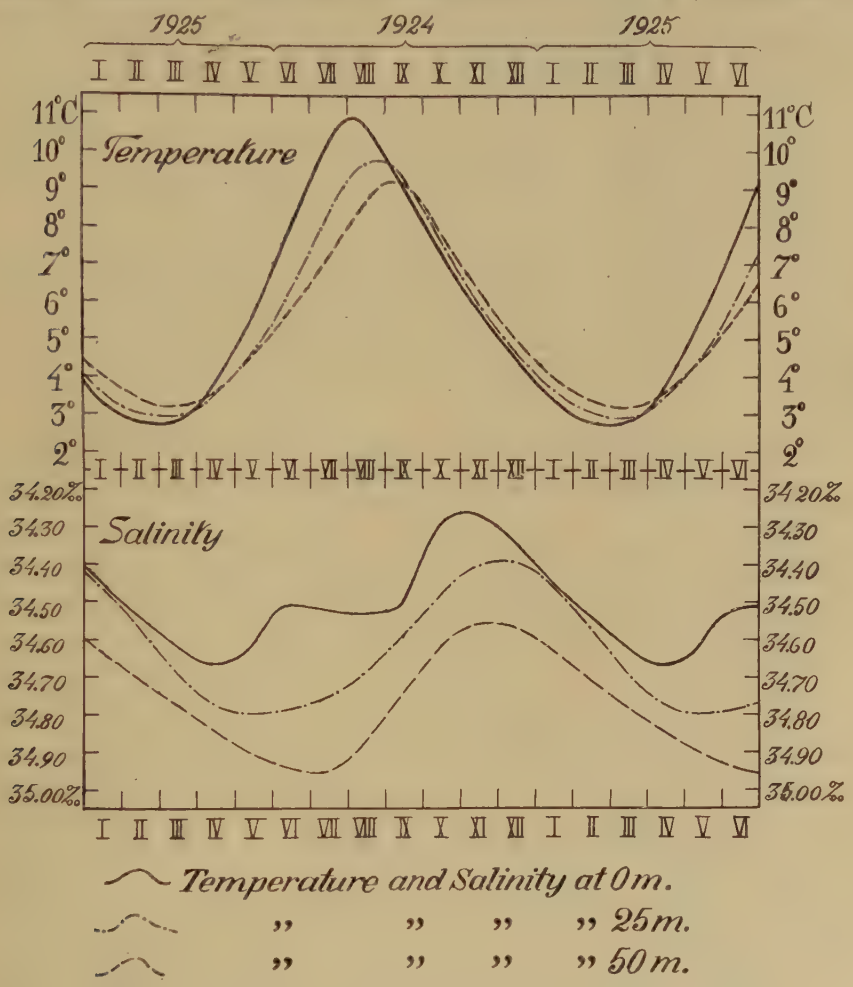

Fig. 50. The yearly variation in salinity and temperature at Akranes station, 1924—1925.

tinuity layer and this is approaching the surface during light winds and calm, and moving farther down with stronger winds, which produce a homohaline upper layer. The discontinuity layer reaches its greatest depth about 2 days after the force of the wind has culminated, the wave movement continuing the mixture of the upper layers.

A highly remarkable feature is that the salter water at 40—50 m. depth is lifted with increasing force of wind. The cause of this must be sought in the

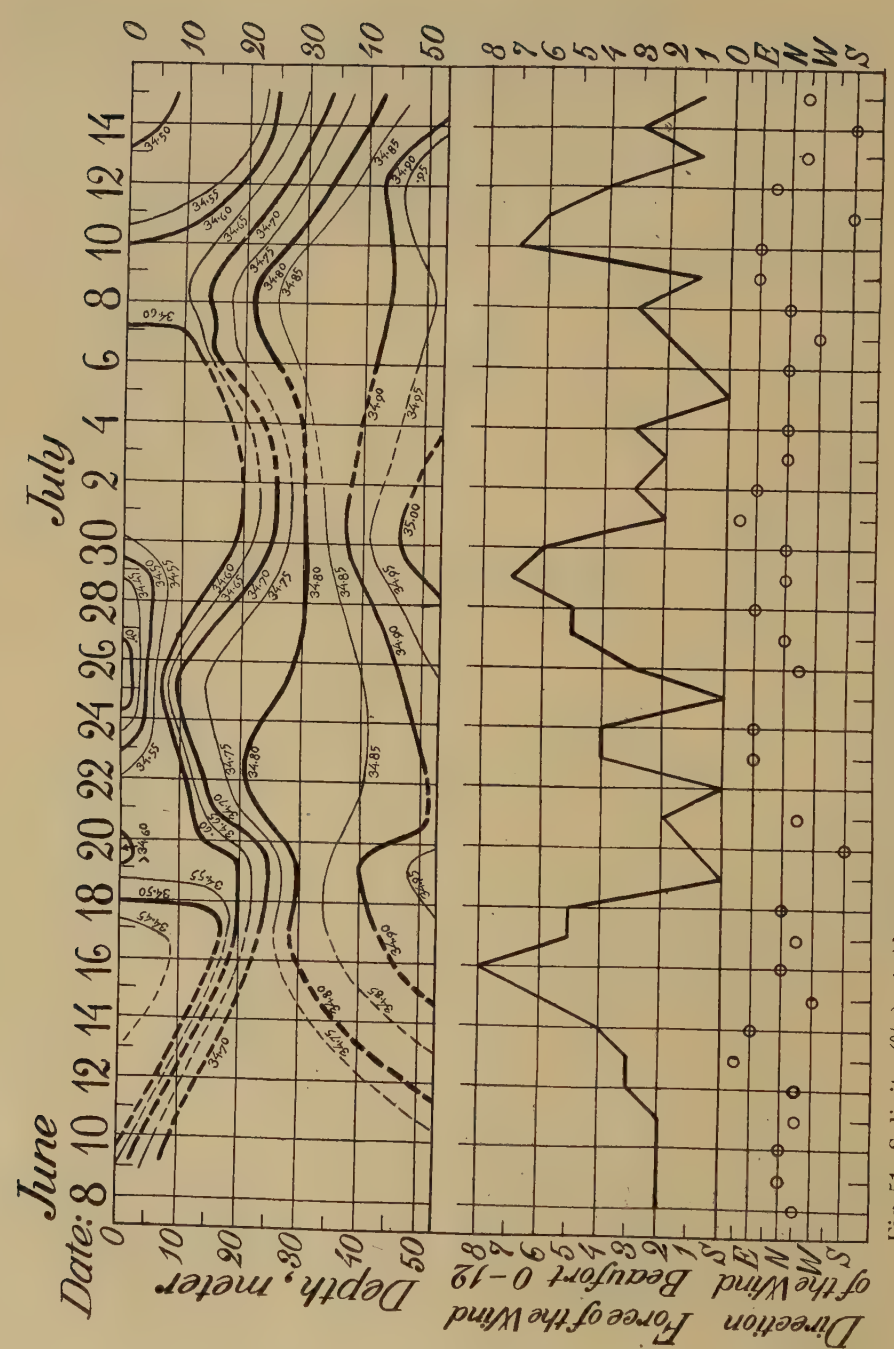
June
July
Date: 8 10 12 14 16 18 20 22 24 26 28 30 2 4 6 8 10 12 14
Depth, meter
0 10 20 30 40 50
Force of the Wind Beaufort 0-12
0 1 2 3 4 5 6 7 8
Direction of the Wind
S W N E S

Fig. 51. Salinity (‰) at Akranes station in the days from 9 June to 15 July and Direction and Force of the wind at Reykjavik in the same time.

mixing conditions under the discontinuity layer, as the water mass below it, as well as that above, it brought in a wave movement and thus becomes mixed. The lower water mass under the discontinuity layer can only obtain additions from the water above to a far less degree, owing to the great difference in specific gravity, than from the salter water at greater depths west and north-west of the station. Thus the mixing proces increases the salinity in the water under the discontinuity layer.

The later observations do not show so distinctly the relation between force of wind and salinity distribution. In the first place, the observations lie so far apart in point of time, that alterations in the salinity cannot be followed with the same degree of accuracy as in June and July 1924; and further, there was a rapid alternation of storm, high winds and light winds during the period.

In fig. 51, the effect of direction of wind is not clearly apparent.

It will be remembered that the distribution of the relatively slightly salt coastal water at Snæfellsnes appeared to be largely dependent on the direction and force of the wind (see p. 76).

We will now proceed to consider whether any effect of direction of wind can also be observed at Akranes Station.

As we know, the coastal water is found in a belt of varying breadth along the coast of Iceland. Variations in its distribution occassioned by the wind might be expected to appear most pronounced in the salinity at the surface.

We have therefore, in the table below, noted the direction and force of the wind in all cases of specially low and specially high salinity at the surface.

		Salinity less than 34.40 ‰				Salinity higher than 34.60‰			
Date of observation:		$^{25}/_{6}$ 1924	$^{28}/_{10}$ 1924	$^{6}/_{11}$ 1924	$^{14}/_{12}$ 1924	$^{19}/_{6}$ 1924	$^{7}/_{7}$ 1924	$^{8}/_{7}$ 1924	$^{21}/_{8}$ 1924
Salinity at surface ‰:		34.36	34.04	34.34	34.40	34.61	34.61	34.63	34.69
Direction and force	3 days before	0	W 1	S 2	SE 3	N 8	N 3	0	SE 1
of the wind during	2 » »	E 4	SE 3	S 4	S 3	NW 5	0	E 1	N 6
the days before the	1 » »	E 4	E 2	S 2	E 5	N 5	E 1	N 2	NE 8
observations	0 » »	0	0	S 4	0	0	N 2	W 3	0

It will be seen that the southerly and easterly winds have brought water of low salinity to Akranes Station, whereas winds about north brought water of high salinity.

3. Current Measurements in Faxe Bay.

Current measurements were made occasionally, in Faxe Bay, at Lat. 64° 16′ N., Long. 23° 14′ W., at 25 metres depth. The depth to bottom here was 90 metres.

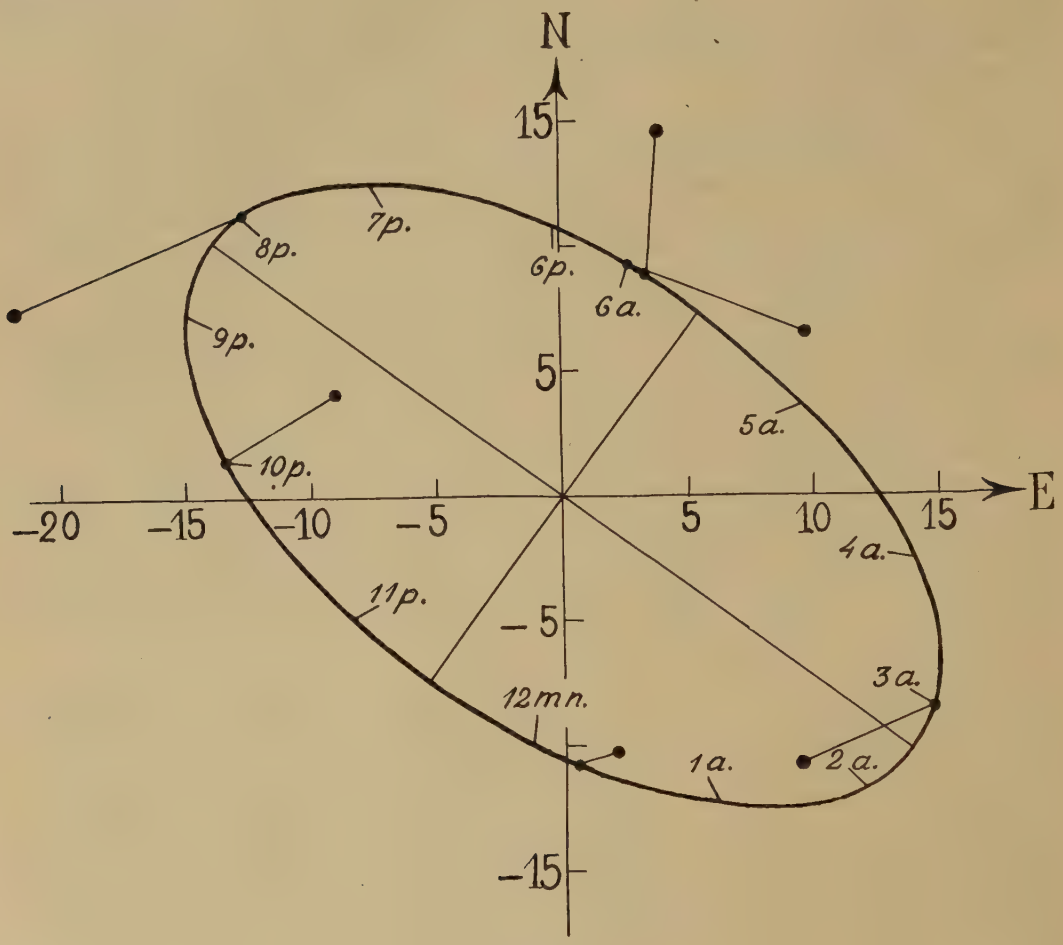

Fig. 52.

In taking these measurements, a buoy with a tall pole (the fixed buoy) was anchored at the spot where the measurements were to be taken. A small buoy intended to drift was fastened by a thin wire 25 metres long to a cylinder made of canvas stretched between two iron rings. The cylinder was 2 metres long and 1 metre in diameter. Owing to the size of the cylinder, it was possible to disregard the influence of the surface current on the buoy, and take it for granted that both buoy and cylinder would follow the current at 25 metres' depth. At the time when the measurements were being taken, the wind was

only slight, (not more than 2 Beaufort) and we could thus also disregard any effect of the wind on the drifting buoy.

At a given hour, the cylinder with buoy attached was cast out at the fixed buoy, the vessel then following the course of the drifting buoy. At different times during its progress, the distance from the fixed buoy was measured by a distance meter, bearings to the fixed buoy being taken at the same time.

After the drifting buoy had covered a suitable distance, it was taken in and cast out anew at the fixed buoy. In this manner it was possible to procure a series of determinations of the distance covered by the drifting buoy at different times, and from this to determine the current. The measurements were taken unintermittently throughout a period of abt. 12 hours from the $^{20}/_{6}$ to $^{21}/_{6}$ 1924. The results are shown in the table below.

Mean time of drifting (local time)	North composant of current, cm/sec. (current reckoned as positive when flowing *towards* the north)	East composant of current cm/sec. (current reckoned as positive when flowing *towards* east)
$^{20}/_{6}$ 5h 32 m p	13.3	3.2
» 8h 31 m »	6.0	—22.6
» 9h 58 m »	2.8	—9.8
$^{21}/_{6}$ 0h 13 m a	—11.5	1.3
» 2h 57 m »	—12.1	8.7
» 6h 01 m »	5.2	9.0

Analysis of these current composants showed that there was a stationary current tending towards S 30 W, velocity 1.5 cm/sec. and also a tidal current, the magnitude of which at different times may be indicated by radii vectores in an ellipse (see Fig. 52) the major axis of which runs from N 54 W to S 54 E. The major axis of the ellipse indicates that the current attained its greatest velocity, 17.9 cm/sec., in a direction towards N 54 W on the $^{20}/_{6}$ at 8.21 p. m. and greatest velocity towards S 54 E on the $^{21}/_{6}$ at 2.33 a. m.

The minor axis of the ellipse shows that the tidal current attained its minimum value, 9.1 cm/sec, on the $^{20}/_{6}$ at 5.15 p. m. in a direction towards N 36 E and minimum towards S 36 W an the $^{20}/_{6}$ at 11.27 p. m.

Disregarding the stationary current, we find the following values for N and E composants, observed and calculated from the ellipse respectively:

Date	Hourshot.	N obs.	N calc.	Diff.	E obs.	E. calc.	Diff.
$^{20}/_{6}$	5h 32m p	14.6	8.8	5.8	4.0	3.4	0.6
»	8h 31m »	7.3	11.3	— 4.0	— 21.8	— 12.8	— 9.0
»	9h 58m »	4.1	1.5	2.6	— 9.0	— 13.4	4.4
$^{21}/_{6}$	0h 13m a	— 10.2	— 10.7	0.5	2.1	0.3	1.8
»	2h 57m »	— 10.8	— 8.6	— 2.2	9.5	14.7	— 5.2
»	6h 01m »	6.5	9.1	— 2.6	9.8	2.8	7.0

In fig. 52, these observed and calculated currents are marked by dots. The lines joining these in pairs indicate the differenses noted in the table.

According to local time, the moon culminated on the $^{21}/_{6}$ at 3.51 a. m. so that the maximum current towards S 54 E occurred 1 hr. 18 min., before the culmination of the moon. According to the »Iceland Pilot«, establisment of port at Reykjavik is 4 hrs. 58 min., so that the maximum currents towards S 54 E occurs simultaneously with low water at Reykjavik, and the maximum current towards N 54 W simultaneously with high water at Reykjavik.

The buoys and distance meter used in the measurements were kindly placed at the disposal of the Commission by the Danish Naval Dockyard authorities.

Investigations of the „Dana" in West Greenland Waters, 1925.

By

Ad. S. Jensen,
Professor of Zoology in the University of Copenhagen.

With an Appendix (List of the Fishes of Greenland).

According to the plan of the Expedition, our main object was to form an idea as to the occurrence of the Cod (*Gadus callarias*) on the banks in Davis Strait, and to investigate the breeding conditions of this species. In both cases, we were successful in procuring information of essential importance.

Pelagic cod eggs were found during the period from 6—23 June in the coastal water, over the banks and outside (fig. 54). Save for a single find, which will be referred to later on, the area of distribution of the eggs extended south to north from 63° 10′ to 66° 45′ N. Lat. i. e. over some $3^1/_2$ degrees of latitude, comprising the following banks: Fiskenæs Bank, Fyllas Bank, Lille Hellefiskebanke and the southern part of the Store Hellefiskebanke. The extent of the area from east to west on the 8—9 June, at 63° 56′ N (outside Godthaab Fjord) was found to be from the coastal water out over Fyllas Bank to the west side of the same (52° 15′—53° 00′ W.); and a little farther west of Fyllas Bank again, at 53° 14′ W, we found floating cod eggs. At 64° 45′ N (Southern part of the Lille Hellefiskebanke) we found on the 20 June that the egg area extended from 53° 13′ to 54° W, or from the eastern to the western side of this bank; three net hauls were made at the same latitude still farther to the west (54° 56′, 55° 17′ and 55° 29′ W) but no cod eggs were found here. At 66° 37′—66° 45′ N (southern portion of the Store Hellefiskebanke) the area was found to extend from 53° 45′ to 56° 52′ W, or from the margin of the land out over the bank to the west of the same; possibly the area may have extended still farther to the west, but if so, the eggs must have been floating under the western ice, as the most westerly haul in which cod eggs were found was made close to the edge of the ice masses in the Labrador current (the Western Ice) which here appeared as a continuous ice field to the north and south, preventing any further use of the apparatus.

The number of eggs in the individual hauls, which were made throughout with a 2 M. stramin net, was not large. The greatest number was taken at St. 2312 (Fiskenæs Bank) over 96 m. depth where a haul of 1 hr. with 200 m. w.

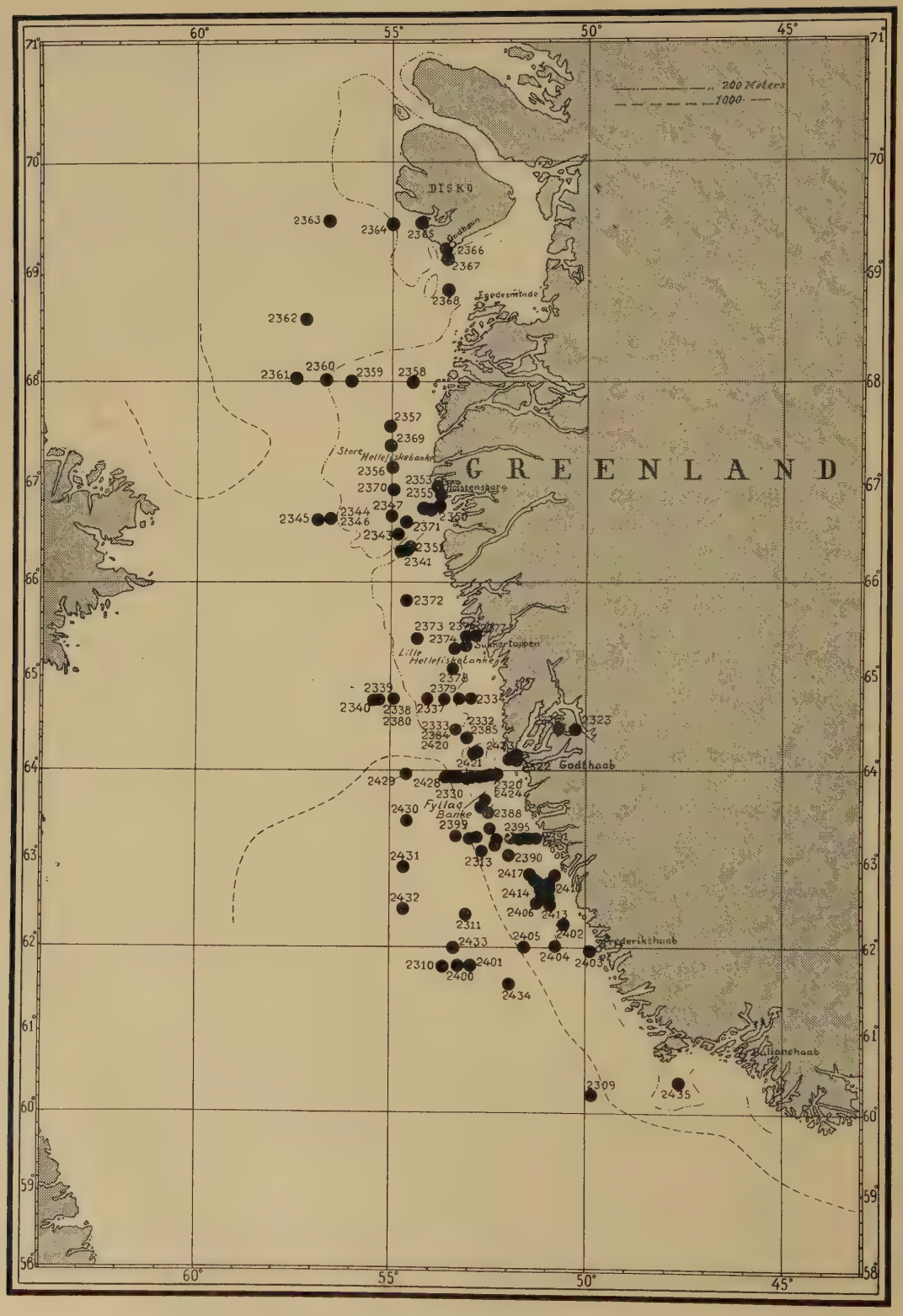

Fig. 53. »Dana« 1925. Stations off the west coast of Greenland.

yielded 48 eggs, 1 hr. with 100 m. w. 162 eggs and ½ hr. with 50 m. w. 80; outside this bank (no bottom at 700 m.) we obtained, at St. 2313, in 1 hr. with 100 m. w. 55 eggs. At St. 2318 (north end of Fyllas Bank, 50 m. depth) a ½ hr. haul with 50 m. w. yielded 45 eggs Otherwise, the highest figures for ½ hr hauls were 20 eggs (St. 2319, eastern side of Fyllas Bank, depth 85 m), 12 eggs (St. 2316, west of Fyllas Bank, no bottom at 1050 m) and 10 eggs (St. 2315, west side of Fyllas Bank, depth 72 m) and at the remaining stations, the no. of eggs never reached two figures. But though the no. of eggs at each station was small, the area in which pelagic eggs occurred was on the other hand of very considerable extent, as will be seen from the foregoing.

No cod eggs were found later than 23 June, either during the period from then to 30 June when the »Dana« was working north of 66° 45′ N, or after that time, when we were operating south of that latitude and in the same area where cod eggs had been met with earlier in the year. The eggs were then all hatched out.

A single find was taken, apparently under other conditions than those of the foregoing, all of which lie inside the banks, over the banks, or a little way outside. This was at St. 2310 (61° 47′ N, 52° 55′ W, depth presumably over 2000 m.) where a 1 hr. haul with 50 m. w. yielded 22 eggs. The chart here shows no indication of any rise in the sea floor; but it must be kept in mind that the depth conditions in the southern part of the Davis Strait are but very little known.

In addition to the mentioned egg fields, on the margin of the land and over the banks — eggs found farther out in Davis Strait over great depths must be presumed to have been carried thither by the coastal current (Polar Current), whose water masses at this time partly move out from the coast towards the west — we found other areas with cod eggs, namely, up in the Godthaab Fjord. During the »Dana«'s first stay at Godthaab, a cruise was made on the 15 and 16 of June with the governor's motor boat up to the base of Pisigsarfik Fjord, to Kapisigdlit, one of the innermost ramifications of the Godthaab Fjord (by the navigable channel some 60 nautical miles from the mouth of the fjord) where the chief of the Government Fishery Department, J. M. Jensen, was then engaged with some natives fishing for cod with nets. Up to that time he had obtained abt. 15,000 kilos, and the cod were then still pursuing the capelan. A ½ hr. haul here made with a 2 M stramin net at the surface over a depth of abt. 80 m, yielded 2712 cod eggs, at all stages. The surface temperature was 9.25° (at bottom 0.81°). At the mouth of Pisigsarfik Fjord we got 14 cod eggs in a ¾ hr. haul. Furthermore, in the outer waters of the Godthaab Fjord, outside the colony, a ½ hr. haul on the 18 June from the »Dana« yielded 4 cod eggs with 100 m. w. and 2 with 50 m. v. As late as the 21 July, a single cod egg was obtained at the same place. Unfortunately, a gale of almost hurricane force during the latter part of the »Dana«'s stay at Godthaab prohibited the contemplated trip to Kapisigdlit by motor boat to ascertain how matters there had developed since our previous visit.

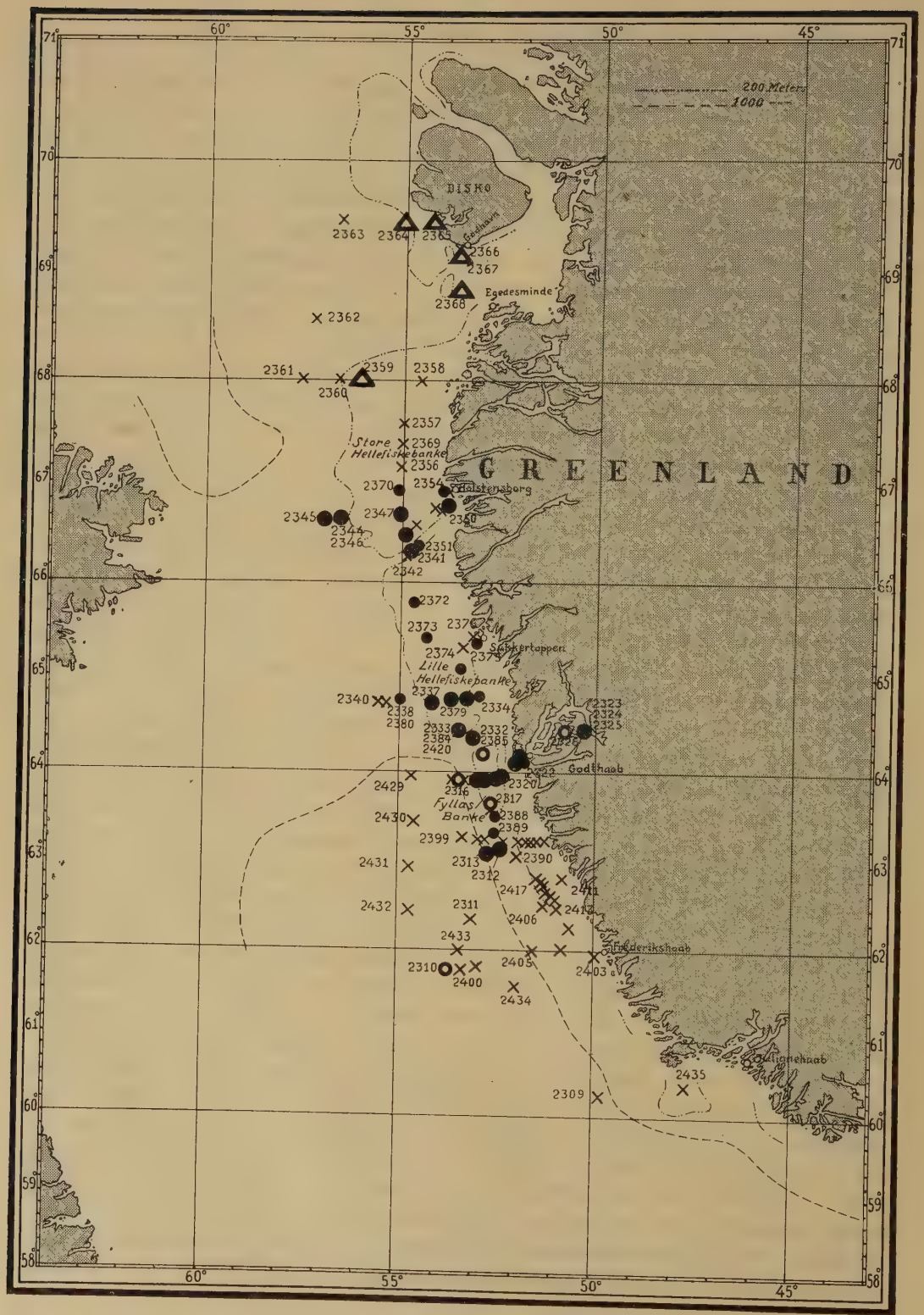

Fig. 54. ● Eggs and postlarval stages of cod *(Gadus callarias)*; • postlarval stages only; ○ eggs only. △ Postlarval stages of Polar cod (*Gadus saïda*). × Negative stations.

In referring the Gadus ova found to *Gadus callarias L.*, and disregarding the closely related Greenland species, *Gadus ogac* Richardson, whose extruded ova are not known, we would point out that *Gadus ogac*, as far as has been ascertained, spawns much earlier in the year, viz. in February and March (see for instance Otto Fabricius, Fauna Groenlandica p. 146). And furthermore, that the northern limit of distribution of the eggs lay at 66° 45′ N, which is precisely the nothern limit of the Greenlanders' coastal fishery for cod established in latter years, whereas *Gadus ogac* extends much farther north, right up to Tasiussak, at 73½° N, and is still of frequent occurrence in the southern part of the Upernivik district, i. e. at 72½° N. Lat. Finally that the eggs as well as the young hatched from them perfectly agreed with *Gadus callarias*.

With regard to the stage of development of the cod eggs, it has already been pointed out that eggs at all stages were found in Kapisigdlit Fjord. 822 of the eggs had as yet no embryo (stage a), some few indeed were still at an early segmentation-stage (unsegmented, 2-celled, 16-celled and 32-celled), the great majority at the blastula-gastrula stage; 400 eggs had a small embryo with short tail and no median fin (stage b), 969 had a larger embryo, tail long with median fin (stage c); 488 had a large embryo with very large but unpigmented eyes, yolk sac still present (stage d); 29 had pigmented eyes, yolk sac not present (stage e).

The cod eggs on the banks likewise embraced all stages a, b, c, d, and e; there were, however, none at the early segmentation-stages, the youngest being at the blastula-gastrula stage.

With regard to the distribution of pelagic fry (see fig. 54) we may say that this on the whole coincided with that of the eggs. They were found — with the exception of St. 2310 already mentioned — together with the first cod eggs at the southernmost station, and accompanied the eggs as far as these occurred to the northward. The northern limit of occurrence of the young fry was very close indeed to that of the eggs, the most northerly finds of eggs being at 66° 45′ (St. 2350) and the most northerly finds of young fry at 66° 45′ (St. 2350), 66° 55′ (St. 2354) and 66° 56′ N (St. 2370).

As already mentioned, we found no cod eggs later on, when the »Dana« after her voyage farther north returned to the scene of the previous finds (south of 66° 45′ N). But the young fry were still there, throughout the entire area down to 63° 21′ N (Fiskenæs Bank).

The number of pelagic fry at the individual stations was on the whole not large. By far the greater number were taken on the southern part of the Lille Hellefiskebanke at a series of stations under 64° 45′ N where the numbers of young fry, reckoning from east to west were: 16 (St. 2334), 18 (St. 2335) 10 and 12 (St. 2336), 19 (St. 2379), 97 and 187 (St. 2337). Otherwise, the largest numbers found were: 24 at St. 2344 (W. of the southern part of Store Hellefiskebanke) and 19 at St. 2382 (on the middle of Fyllas Bank). At the remaining stations, the

numbers never ran into two figures. All were taken in half-hour hauls with 2 m. stramin net and 50 or 100 m. w.

The size of the young fry ranged from 5 to 13 mm. The finds cover a period of about a month ($^{7}/_{6}$—$^{6}/_{7}$) and the latest captures were also the largest in size, specimens of only 5 or 6 mm being very rare in July, and those of 11—13 mm found only during that month.

A point worth noting, to my mind, is the fact that the eggs were found in greatest numbers in the southern parts of the area, Fiskenæs Bank and Fyllas Bank, whereas the young fry were most abundant farther north, on the southern part of the Lille Hellefiskebanke. This might perhaps suggest that the coastal current (the Polar Current) carries the young fry — as well as eggs, which hatch out on the way — on its course, in such a manner as to dislocate their relative numbers somewhat in a north-westerly direction. Should this prove to be the case, it might also serve to explain another remarkable phenomenon, to wit, the absence of young fish in the southern parts after a certain date. As late as 6 July, a few (8) young specimens were captured at the southern end of Fyllas Bank (St. 2388) and on the 7 July a single specimen on the Fiskenæs Bank, but after that, no more young fry were found on these banks. Numerous hauls were made: 7—8 July at Fiskenæs Bank (St. 2390, 2391, 2397, 2398, 2399), 9—10 July outside Frederikshaab, close in to shore and farther out in Davis Strait (St. 2400, 2401, 2402, 2403, 2404, 2405), 11—12 July at a bank we discovered outside Ravns Storø (St. 2406, 2413, 2417), 12 July at Fiskenæs Bank (St. 2418), 14 July at Fyllas Bank (2421, 2422) and, after our stay in Godthaab, on the 21 July again on Fyllas Bank (St. 2425). All these, however, proved fruitless; not a single young fry was taken in any of the hauls. The season meantime was so far advanced that unfortunately we were unable to prosecute the investigations further, as the vessel had to get clear of the Greenland waters. All we could do was to make a series of hauls on our way south, out in Davis Strait, west of Fyllas Bank and the other southerly banks, in some cases as far out as 54° 39′ W (St. 2428, 2429, 2430, 2431, 2432 and 2433). No young fry, however, were found.

From the foregoing then, it seems to me not altogether unlikely that the disappearance of the young fry from the southern banks may be due to their being carried by the coastal current (the Polar Current) in a north-westerly and westerly direction. The fry would most likely be too small and weak to make any active migration eastward, in the direction of the land.

As regards Godthaab Fjord, young fry were found both in the inner and outer portions of the fjord. At Kapisigdlit, on the $^{15}/_{6}$, we got 9 young fry of 5—8 mm in the same haul, which as mentioned, also yielded 2712 cod eggs. And in the outer part of Godthaab Fjord, outside the colony we obtained at St. 2328 ($^{18}/_{6}$) 21 young fry (5—8 mm) with 100 m. w. and 2 (5—5.5 mm) with

50 m. w.; at St. 2423 ($^{21}/_{7}$) 5 young fry (10—16 mm) with 100 m. w. and 1 (7 mm) with 50 m. w. all in half hour hauls.

Fishing Experiments for Cod were, owing to the short time we had to work in, made chiefly with hand lines, which have the great advantage of indicating rapidly the occurrence and numbers of the cod. Where opportunity occurred, long line and trawl were used. The latter could only be used in deep water, the bottom on the banks being too hard and stony.

On the 7 June, the »Dana« was on the bank outside Fiskenæs, but stormy weather prevented our making any fishing experiments. On the 8—10 June we were on Fyllas Bank, and tried here on the middle of the bank and at its west, south, north and east sides, but the place was found to be practically empty of fish. Hand lines gave no result, and a long line of 500 hooks, baited with good frozen herring, yielded only 2 cod. The bank was at this time covered with polar water of low temperature, 0.20°—0.82° C. at bottom (surface 0.39°—0.81° C.). On the 18 June we fished again without result. The temperature had risen to 0.30°—1.06° C. at bottom (surface 1.40°—1.49°). On the 4, 5 and 6 July the »Dana« was again on Fyllas Bank, where the bottom temperature had now risen to 0.87°—1.68° C. (surface 2.84°—3.43° C.) and the cod had now moved in on to the bank.

Hand lines yielded at:

St. 2382, depth 53 m 84 cod taken by 5 men in 2 hours.
» 2386, » 50 » 185 » — » 5 » » 5 »
» 2387, » 53 » 159 » — « 5 » » 4 »

On the 13 and 14 July, the bottom temperature had risen to 2.09° (surface 2.73°) and on the 21 July to 2.74° (surface 3.15°); fishing experiments showed that there were still cod on Fyllas Bank.

The influence of the bottom temperature on the movements of the cod in to the banks was further apparent on comparing the results of three experiments made with hand lines at the southern end of the Lille Hellefiskebanke (depth 65—89 m), made at the same place, but at different times, and consequently with different temperatures at bottom:

19 June, bottom temp. 0.38°, yielded 0 cod.
5 July, » » 0.31°, » 1 »
13 July, » » 1.09°, » 88 »

On the 19 July, we tried various other places on the Lille Hellefiskebanke; the bottom temperature was very low, ÷ 0.04°—0.28°, and no captures were made. On the 23—26 June we tried at several places up over the Store Hellefiskebanke to its northern end (68° N); here also the bottom temperature was very low ÷ 0.54°—0.56° and no cod were found anywhere here. On the 3 July we again

tried the Lille Hellefiskebanke, where the bottom temperature had risen to 0.43°, but no cod were found.

At the beginning of July, when the bottom temperature on Fyllas Bank had risen to 0.87°—1.68°, it was considerably lower on the more southerly bank off Fiskenæs, viz. 0.32°—0.47°, and 7 fishing experiments made on the 6—7 July in different places (depth 56—105 m) showed that the stock of fish here was considerably smaller than on Fyllas Bank, the yield being only 0 to 9 fish in each case.

Further south again, at 62° 30′—62° 47′ N, 50° 47′—51° 19′ W, the »Dana« discovered and sounded, as already mentioned, a new bank, with depth from 51—110 m and here the bottom temperature was still lower, viz. ÷ 0.13°— ÷ 0.79°. On the 11 and 12 July we made nine fishing experiments here, eight of them gave only a few cod (0, 0, 0, 1, 3, 4, 4, 7) but at one place, depth 60 m, the fish were closer together, 4 men taking 101 cod in 7 hours.

The most southerly spot we fished was 61° 57′ N 49° 55′ W, close in to shore outside Frederikshaab. The experiment here, at 60—140 m depth, with a bottom temperature of 0.09° yielded only 3 cod.

Summing up the result of the foregoing fishing experiments we find the following:

Fyllas Bank was by far the most favourable for the cod fishery. The fish arrived earlier here, and were also more numerous, than on any of the other banks. This was evidently due to its position, which occasioned a rise of temperature in early summer sooner and higher than on the other banks. This again is due to the following facts:

The icy Polar Current of East Greenland is, on reaching the southern point of Greenland, forced by the earth's rotation to turn up to the north-west along the south-west coast. This coastal current carries with it, as we know, in spring and early summer considerable quantities of ice (the »Storis«, or Great Ice). But the temperature of this polar current rises as it flows further north, owing to the melting of the ice, and the heat of the sun can then accumulate in the water instead of being dissipated in further thawing.

This year, the great ice had melted before reaching Fyllas Bank; we found, however, considerable quantities of ice farther south (as late as 10 July there was still Great Ice outside Frederikshaab). The Polar current has thus brought cold water to the southern banks, whereas Fyllas Bank had its water masses warmed comparatively early and rapidly.

The unfavourable temperature conditions also found on the Lille and Store Hellefiskebanke, which lie farther north, are not due to the East Greenland Polar current; the cold water found here must be presumed to have been formed on the spot by intensive cooling during the severe winter which had passed.*)

*) The steamer »Hans Egede«, belonging to the Greenland Trading Company, encountered, at the end of April, close packed winter ice in Davis Strait between Sukkertoppen

Fyllas Bank was thus — and, I suppose, generally will be — exceptionally favoured by its position, being free from pack ice in winter and drift ice in summer.*)

During the period of our investigations — i. e. until the 21 July — the position of the cod fishery after the first appearance of the cod on the banks was roughly as follows:

Even on Fyllas Bank, where most cod were found, the fishery varied, giving sometimes many cod, at others only few. It was fishing by fits and starts. We might lie out a long while without getting anything much, then suddenly the cod would begin coming up one after another over the side. These good spells, however, rarely lasted for any length of time, but soon dropped off again. In other words, the fishery was altogether irregular. And there is the further point to be noted — which would prove a difficulty in the event of the fishery being further developed — that Fyllas Bank is of slight extent, being but 16 miles across and 40 long, or not much larger than Faxe Bay, Iceland. It falls away steeply on all sides down to great depths, with no shelving transition between. The bank is too small to accomodate many vessels fishing together for any length of time. And if this restricted area were constantly worked by trawlers furnished with bobbins crossing and re-crossing, the stock of fish would probably soon be destroyed.

The other banks where any cod were found at all were much poorer than Fyllas Bank.

We see then, that although the banks in Davis Strait did not this year fulfil the requirements for fishery on a large scale, they may nevertheless be of great importance to the Greenlanders, who can work from a base on shore at various places and operate economically with small craft. The natives, being close to the banks, have a great advantage over others coming from distant parts, in that they are able easily and rapidly to ascertain when the cod arrive on the banks, and whether they are abundant; thus if the natives see their profit in it bank fishery could be conveniently combined with the fjord and coast fishery.

Investigation of the stomach contents of cod found on the banks showed that this consisted in most cases, and for by far the greater part, of crabs *(Hyas)*; Polychæta were also frequently found to form a part of the diet. Many other lower animal forms were also found in the stomachs, such as *Crangon, Pandalus* and other kinds of shrimp, amphipods, holothurians, mussels etc. Among the remains of fish it was possible to distinguish the Long rough Dab *(Hippoglossoides platessoides)*, Sandeels *(Ammodytes lancea)*, Catfish *(Anarrhichas), Pholis, Gymnelis* and various species of Sea-scorpion. Fish remains, however, did not constitute any essential part of the stomach contents, the crabs being as mentioned greatly predominant. There

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and Holstensborg, and suffered some damage in the difficult process of breaking a way through. It was then freezing 16°.

*) The peculiar hydrographical conditions have been elucidated by the fine work of Dr. J. N. Nielsen in his investigations in West Greenland with the »Tjalfe« expedition.

seemed to be some slight difference in this respect between the different banks, fish remains being comparatively frequent in the specimens from the southern end of the Lille Hellefiskebanke.

As regards the size of these bank cod we may state as follows:

The average size of 116 cod from Danas Bank was 87.66 cm, 27 from Fiskenæsbank 93.37, 281 from Fyllas Bank 96.64, 87 from Lille Hellefiskebanke 101.60. It seems then as if the average length increases from south to north.

Investigation of the genital organs showed that the females were spent; in some few cases atrophied (white) ova were found remaining in the ovaries from the spawning time; one female still contained a small quantity of ova not yet spawned. The males were also for the most part spent; there were, however, not a few with fluid sperma still present in the testes.

With a view to ascertaining whether Greenland is visited by cod from other waters in addition to those which breed on its shores, we marked and liberated abt. 300 specimens on the south end of Lille Hellefiskebanke, Fyllas Bank and Danas Bank.

As already mentioned, the Fjord Cod *(Gadus ogac)* spawns earlier, in February and March; the expedition therefore arrived on the spot too late to obtain any data as to the eggs and early stages of this fish. We obtained, however, by the use of seines at the ports we touched, a considerable amount of material for study of the growth of this species.

Pelagic young of the Polar Cod *(Gadus saida)* were found only at the most northerly stations, north of Lat. 68° (fig. 54).

The first occurrence was at St. 2359: 68° 05′ N, 56° 00′ W. Only 4 specimens were found here, over a depth of 149 m.

It was taken in greater numbers west and south of Disko Island, as follows:

St. 2364, 69° 28′ N, 55° 00′ W, depth 152 m, 141 specimens.
St. 2365, 69° 28′ N, 54° 16′ W, depth 66 m, 302 specimens.
St. 2367, 69° 10′ N, 53° 32′ W, depth 270 m, 317 specimens.
St. 2368, 68° 52′ N, 53° 32′ W, depth 775 m, 239 specimens.

They were taken from 26—29 June, in half-hour hauls at each station, with a 2 m stramin net and 50 and 100 m. w. The specimens were 9—18 mm long.

The investigations on Halibut *(Hippoglossus vulgaris)* confirmed the results of the »Tjalfe« expedition in 1908 and 1909 showing that this fish in spring keeps to the deep, and continually »warm« water off the Store Hellefiskebanke. On the 22 June, when the bottom temperature at Store and Lille Hellefiskebanke was abt. 0°, the bottom water of the submarine ridge running across towards America almost under the Arctic Circle, showed a temperature of a good

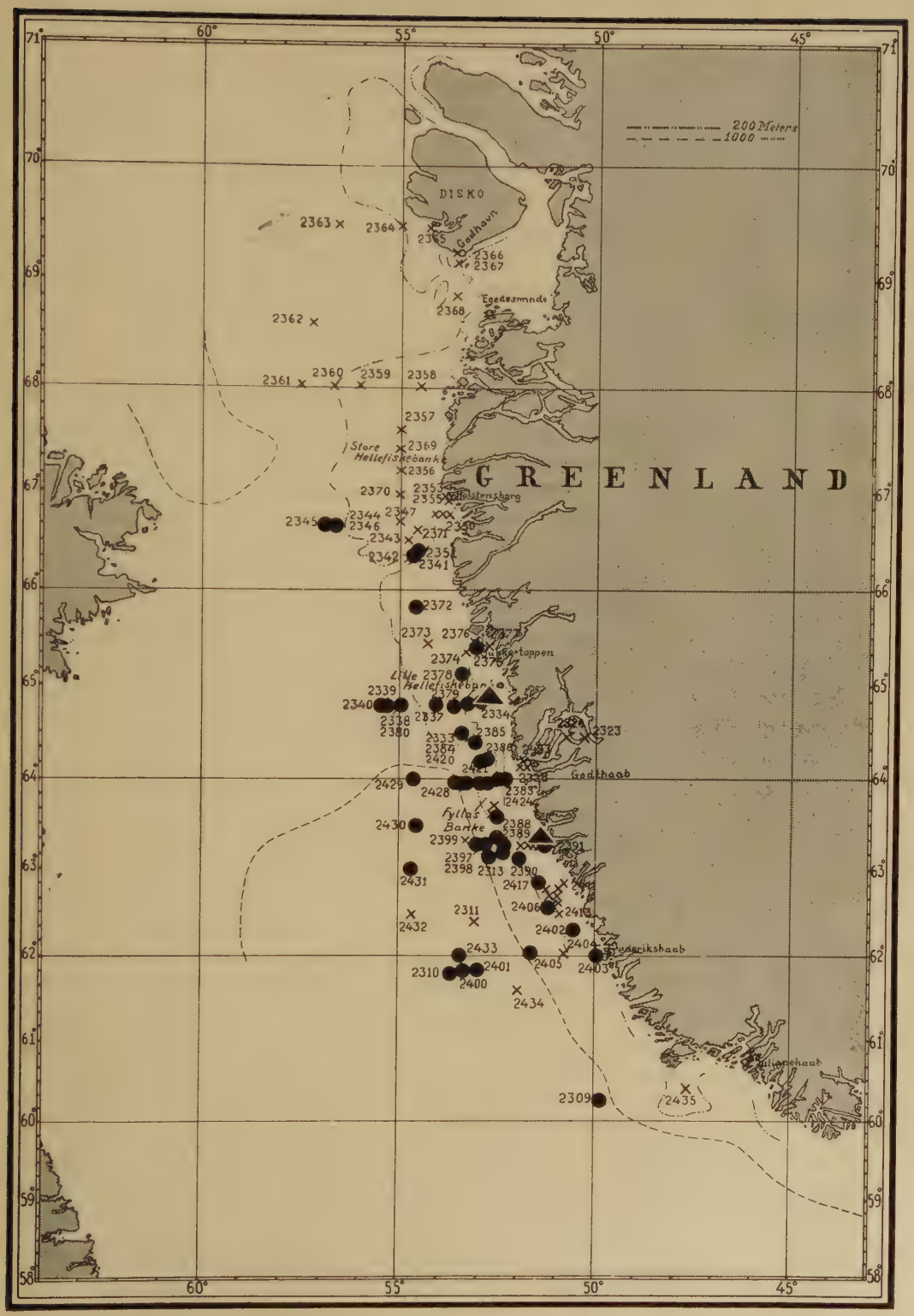

Fig. 55. ● Postlarval stages of Greenland Halibut *(Reinhardtius hippoglossoides)*.
▲ Postlarval stages of Halibut *(Hippoglossus vulgaris)*.

3°, and here, at depths of 450—500 m, several halibut were taken, some with long lines, others in the trawl. Not until later on, when the temperature had risen, did the halibut move up on to the banks and in towards land, so that from the beginning of July, we took halibut pretty regularly on the lines when fishing for cod. We found them in greatest numbers on the southern part of the Lille Hellefiskebanke, where a fishing experiment on the 13 July yielded 40 halibut against 88 cod, or 23½ % halibut. On Fyllas Bank 3.3 % of the catch consisted of halibut, on the Fiskenæs Bank 11½ %. Danas Bank and the grounds off Frederikshaab yielded no halibut.

As a novelty in Greenland the expedition reports having succeeded in taking pelagic fry of halibut.

A specimen 14.75 mm long was taken on the 19 June at St. 2334, 64° 45′ N, 52° 52′ W (east of Lille Hellefiskebanke), at the surface (50 m. w.) over a depth of 506 m. Another somewhat larger, 21 mm, was taken on the 7 July at St. 2391, 63° 13′ N, 51° 17′ W. (shore ground 3 miles off the Inugsugtut islands), 25—50 m below the surface (100 m. w.) over a depth of only 56 m (fig. 55).

These finds show that the halibut breeds in West Greenland waters.

In a paper »On the Fishery of the Greenlanders« recently published*), I have given an account of the occurrence and development of the Greenland Halibut *(Reinhardtius hippoglossoides)*; it does not breed in the fjords or bays of Greenland where the adult fish are caught, but out in Davis Strait, south of 66° ¾ N. In the spring of 1908 and 1909, the »Tjalfe« expedition found Greenland Halibut with roe mature (4—4.5 mm diameter) at depths of 480—800 m, and also young stages just out of the egg, these last being found close to the bottom (bathypelagically) in that part of the Davis Strait where the depth is abt. 680—1660 m (62° 53′—66° 45′ N lat.). As time goes on, the young fish move higher up in the water until they reach nearly to the surface. These surface stages are found not only over great depths, but also over the shallow coastal banks, and are at any rate pelagic until a length of 57 mm is reached; in all probability, their pelagic life continues until they reach a length of abt 80 mm.

In 1925, we had hardly any time for deep water hauls, but we obtained a quantity of surface stages of the Greenland Halibut in the nets. At no fewer than 54 stations, ranging from 60° 13′—66° 38′ N. we found these pelagic young, partly over great depths outside the banks, partly scattered by active migration inwards to the banks and coastal waters (fig. 55). The length of the specimens was on the 5—23 June 16—28 mm, and from 1—22 July 18—49 mm**).

Valuable information as to the habitat of the young Greenland Halibut in the bottom stage was afforded by the finds at St. 2363, where a trawling haul

*) Meddel. fra Komm. f. Havundersøgelser, Serie Fiskeri Bd. VII No 7, 1925.

**) From 23—30 June, the expedition was working north of 66° ¾ N. and we found no pelagic young of the Greenland Halibut here.

of one hour's duration made on the 27 June west of Disko (69° 30′ N, 56° 32′ W) at a depth of 202 m and on soft bottom, brought up 666 small specimens, 85—125 mm long, the great majority (493 spec.) being 100—110 and evidently representing the I group.

Pelagic eggs of the Long rough Dab (*Hippoglossoides [Drepanopsetta] platessoides)* were found as far south as 61° 47′ N, and as far north as 69° 10′ N., i. e. throughout almost the whole of the range covered by the expedition. They were found in greatest numbers on the Fiskenæs Bank, Fyllas Bank, between Fyllas Bank and Godthaab Fjord, in Godthaab Fjord itself, over the channel between Lille and Store Hellefiskebanke, outside Ikertok Fjord and off Holstensborg. The greatest no. of eggs, taken in a half hour haul with 50 or 100 m. w. was 287 + 135 in Godthaab Fjord outside the colony, and 233 + 156 outside Ikertok Fjord; several of the other localities mentioned yielded over 100 eggs in one haul. The eggs were mostly hatched out by the end of June, but on the 21 July we still found an occasional egg. The young fish themselves were first met with on the 19—20 June, and were then 5—9 mm; on the 21—22 Juli they were 6—15 mm long.

Pelagic young of the Norway Haddock *(Sebastes marinus)* were found from 7 June to 9 July at 19 stations, situated between 61° 47′ and 66° 38′ N, partly over great depths in Davis Strait (down to over 3000 m) but also over lesser depths on the Fiskenæs Bank, Fyllas Bank, southern part of Lille and Store Hellefiskebanke.

By far the greatest numbers (42 and 65) were taken at St. 2337 (southern part of Lille Hellefiskebanke, depth 130 m), the next in order of numbers (24) being St. 2335 (eastern side of Lille Hellefiskebanke, depth 150 m). None of the other stations yielded a number of specimens reaching two figures.

The fish were 7—17 mm long; the sizes from 13—17 were only met with at the later stations.

In 1908 and 1909, having investigated the same waters without finding any young stages of this species in spring or summer, I put forward the theory*) that it did not spawn in West Greenland waters, and that the older pelagic fry which I found there in the autumn must have been carried by the current from Danmark Strait, where newly hatched young are found in the spring in great abundance. We see, however, from the foregoing, that the Norway Haddock did spawn in West Greenland waters in 1925, and my former theory cannot therefore be regarded as generally valid.

Besides young of the species mentioned already, we found several others, which were preserved for subsequent and more detailed investigation, including *Cottus, Icelus, Agonus, Aspidophoroides, Pholis, Lumpenus, Stichæus, Anarrhichas, Ammodytes, Macrurus, Cyclopterus, Liparis, Mallotus.*

*) Vidensk. Meddel. fra Dansk Naturh. Forening, Bd. 74, 1922, p. 90.

Difference of the Fish Fauna in deep water South and North of the Greenland-Baffin Land ridge.

In the narrowest part of Davis Strait there is, as we know, a submarine ridge connecting Greenland with Baffin Land. Its deepest part lies abt. 600 m below the surface, thus forming a barrier between the deepest parts of Baffin Bay and the sea west of southern Greenland. The ridge does not, however, offer any obstacle to the interchange of the upper water masses. Consequently, the warm north-going current found under the ice-bearing Labrador Current in the western part of Davis Strait can pass over the ridge and proceed up Baffin Bay, though its temperature and salinity become considerably reduced in course of time.

This feature, which has been elucidated by the hydrographical observations of Dr. J. N. Nielsen, might be supposed to affect the composition of the fauna on the respective sides of the ridge. A comparison of two trawl stations from the »Dana« expedition, one on either side, will serve to show the remarkable difference which actually exists, despite the fact that the difference in latitude only amounted to $1^1/_2{}^0$, and in temperature and salinity was small or nil on the days of investigation ($^{22}/_6$ and $^{26}/_6$).

St. 2346. 66° 37′ N. 56° 37′ W. Depth: 450m. Bottomtemperature 3,12°. Salinity 34,70.	St. 2361. 68° 08′ N. 57° 30′ W. Depth 400 m. Bottomtemperature 2,47°. Salinity 34,70.
Myxine glutinosa L. (1)	
Centroscyllium Fabricii Reinhardt (42)	
Raja lintea Fries (13)	
Raja spinicauda Jensen (2)	
Raja Fyllae Lütken (16)	
Raja radiata Donovan (7)	*Raja radiata* Donovan (4)
Synaphobranchus pinnatus Gray (1)	
Macrurus (Coryphænoides) rupestris Gunnerus (262)	
Macrurus Fabricii Sundevall (46)	*Macrurus Fabricii* Sundevall (1, juv.)
	Gadus saida Lepechin (2)
Gaidropsarus (Onus) argentatus Reinhardt (1)	*Gaidropsarus (Onus) argentatus* Reinhardt (1)
Reinhardtius (Platysomatichthys) hippoglossoides Walbaum (16)	*Reinhardtius (Platysomatichthys) hippoglossoides* Walbaum (40)
Hippoglossus vulgaris Fleming (2)	
Hippoglossoides (Drepanopsetta) platessoides Fabricius (5)	*Hippoglossoides (Drepanopsetta) platessoides* Fabricius (20)
Pleuronectes cynoglossus L. (2)	
Sebastes marinus L. (102)	*Sebastes marinus* L. (83)

Cottunculus microps Collett (4)
Cottunculus Thomsoni Günther (2)
Agonus decagonus Bloch-Schneider (2)

Anarrhichas denticulatus Krøyer (7)

Lycodes Esmarkii Collett (3)

Artediellus uncinatus Reinhardt (117)
Cottunculus microps Collett (6)

Agonus decagonus Bloch-Schneider (11)
Cyclopterus spinosus Fabricius (1)
Lumpenus (Leptoclinus) maculatus Fries (1)

Anarrhichas minor Olafsen (4)

Lycodes Vahlii Reinhardt (19)
Lycodes eudipleurostictus Jensen (4)

It will at once be noted that St. 2346 gives a number of species which are not found at St. 2361, while this latter station again has some few species not found at the former.

Apart from *Anarrhicas denticulatus,* the absence of which at St. 2361 is probably accidental, we find that St. 2346 has the following species not found at St. 2361:

Myxine glutinosa
Centroscyllium Fabricii
Raja lintea
Raja spinicauda
Raja Fyllae
Synaphobranchus pinnatus
Macrurus (Coryphænoides) rupestris
Hippoglossus vulgaris
Pleuronectes cynoglossus
Cottunculus Thomsoni
Lycodes Esmarkii

All these 11 species are decidedly Atlantic forms, and their presence at St. 2346 gives this an Atlantic character, since they constitute more than half the species found there, the others being either species of wide distribution, such as *Raja radiata* and *Hippoglossoides platessoides,* or those which, although properly Atlantic, penetrate some way into the Arctic region, like *Macrurus Fabricii* and *Sebastes marinus,* with, finally, some which are more or less arctic.

At St. 2361, the decidedly Atlantic forms are entirely lacking, and we find, on the other hand, such arctic forms as *Gadus saida* and *Lycodes eudipleurostictus,* which, in conjunction with the other more or less arctic forms gives the station a semiarctic—arctic character.

On the southern side of the Greenland Baffin Land ridge, then, we have a fish fauna predominantly Atlantic in character, with some admixture of more or less arctic elements, whereas on the north side of this ridge, we find a fauna lacking the decidedly Atlantic elements and of a semiarctic—arctic character generally.

Even more conspicuous is the difference between the bathypelagic fish fauna north and south of the ridge.

A net haul with 600 m. w. at St. 2361, north of the ridge, yielded no fish at all; at St. 2346, however, south of the ridge, we obtained *Scopelus glacialis* and *Sc. arcticus.*

In the course of the »Dana« expedition, other net hauls were made in the deep waters of Davis Strait south of the ridge, with 500, 1200, 1500 and 1900 m. w. the result of these hauls being the species as under:

Bathylagus Benedicti Goode & Bean.
Cyclothone microdon Günther
Stomias boa Risso
Scopelus (Myctophum) glacialis Reinhardt
Scopelus (Myctophum) arcticus Lütken
Scopelus (Lampanyctus) crocodilus Risso

all these being characteristic of the bathypelagic fauna of the North Atlantic.

The bathypelagic fish fauna of Davis Strait south of the ridge also includes, as previously mentioned, the first young stage of *Reinhardtius hippoglossoides* Walb.

North of the ridge, I have only found a single bathypelagic fish form, namely *Scopelus glacialis* Reinh., of which I found 8 specimens in 1908, at 70° 41′ N, 52° 07′ W, with 800 m. w. over a depth of 800 m.

POSTSCRIPT.

As mentioned p. 94 some cod were marked and liberated from the »Dana« off West Greenland. A list of the specimens marked and re-caught follows:

St. 2382. Fyllas Bank. 63° 56′ N. 52° 41′ W. 4. 7. 1925.
28 specimens marked.
4 of which re-caught in 1925 on Fyllas Bank 9—24. 7.

St. 2386. Fyllas Bank. 64° 11′ N. 52° 47′ W. 5. 7. 1925.
77 specimens marked.
3 of which re-caught in 1925 on Fyllas Bank 9—22. 7.

St. 2387. Fyllas Bank. 63° 36′ N. 52° 34′ W. 6. 7. 1925.
75 specimens marked.
5 of which re-caught in 1925 on Fyllas Bank 8—28. 7.

St. 2408. Danas Bank. 62° 37′ N. 51° 02′ W. 11. 7. 1925.
60 specimens marked
none of which re-caught in 1925.

St. 2420. Lille Hellefiskebanke. 64° 25′ N. 53° 24′ W. 13. 7. 1925.
51 specimens marked.
3 of which re-caught in 1925: 1 spec. on Lille Hellefiskebanke 15. 7; 1 spec. on Fyllas Bank c. 15. 7; 1 spec. in the »Davis Strait« 21. 7.

Appendix.

List of the Fishes of Greenland.

Myxine glutinosa L.
Petromyzon marinus L.
Centroscyllium Fabricii Reinhardt
Squalus acanthias L.
Somniosus microcephalus Bloch-Schneider
Raja radiata L.
Raja hyperborea Collett
Raja Fyllae Lütken
Raja lintea Fries
Raja spinicauda Jensen
Clupea harengus L.
Salmo salar L.
Salmo alpinus L.
Nansenia groenlandica Reinhardt
Bathylagus Benedicti Goode & Bean
Mallotus villosus Müller
Cyclothone microdon Günther
Argyropelecus Olfersi Cuv.
Stomias ferox Reinh.
Anguilla rostrata Le Sueur
Synaphobranchus pinnatus Gray
Histiobranchus infernalis Gill
Saccopharynx ampullaceus Harwood
Paralepis borealis Reinhardt
Paralepis Kröyeri Lütken
Scopelus (Myctophum) glacialis Reinhardt
Scopelus (Myctophum) arcticus Lütken
Scopelus (Lampanyctus) elongatus Costa
Scopelus (Lampanyctus) crocodilus Risso.
Plagyodus (Alepisaurus) ferox Lowe
Notacanthus Chemnitzii Bloch
Notacanthus (Macdonaldia) rostratus Collett
Lampris guttatus Brünn.
Gasterosteus aculeatus L.
Ammodytes lancea Cuvier
Macrurus Fabricii Sundevall
Macrurus Goodei Günther
Macrurus æqualis Günther
Macrurus (Coryphænoides) rupestris Gunnerus
Trachyrhynchus Murrayi Günther
Gadus callarias L.
Gadus ogac Richardson
Gadus virens L.
Gadus saida Lepechin
Haloporphyrus eques Günther
Brosmius brosme Ascanius
Gaidropsarus (Onus) argentatus Reinhardt
Gaidropsarus (Onus) ensis Reinhardt

Gaidropsarus (Onus) septemtrionalis Collett
Antimora viola Goode & Bean
Orcynus thynnus L.
Aphanopus minor Collett
Hippoglossus vulgaris Fleming
Reinhardtius (Platysomatichthys) hippoglossoides Walbaum
Hippoglossoides (Drepanopsetta) platessoides O. Fabricius
Pleuronectes cynoglossus L.
Sebastes marinus L.
Cottunculus microps Collett
Cottunculus Thomsoni Günther
Gymnacanthus tricuspis Reinhardt
Cottus scorpius L.
Cottus scorpioides O. Fabricius
Cottus quadricornis L.
Artediellus uncinatus Reinhardt
Icelus bicornis Reinhardt
Triglops Pingelii Reinhardt
Agonus decagonus Bloch-Schneider
Aspidophoroides monopterygius Bloch
Aspidophoroides Olrikii Lütken
Cyclopterus lumpus L.
Cyclopterus spinosus O. Fabricius
Liparis liparis L.
Liparis liparis L. var. Fabricii Krøyer
Careproctus Reinhardti Krøyer
Paraliparis pellucidus n. sp.
Anarrhichas lupus L.
Anarrhichas minor Olafsen
Anarrhichas denticulatus Krøyer
Lumpenus medius Reinhardt
Lumpenus Fabricii Reinhardt
Lumpenus (Leptoblennius) lampetriformis Walbaum
Lumpenus (Leptoclinus) maculatus Fries
Pholis gunellus L.
Pholis fasciatus Bloch & Schneider
Stichæus punctatus O. Fabricius
Eumesogrammus præcisus Krøyer
Lycodes Vahlii Reinhardt
Lycodes Esmarkii Collett
Lycodes eudipleurostictus Jensen
Lycodes pallidus Collett
Lycodes reticulatus Reinhardt
Lycodes seminudus Reinhardt
Lycenchelys Kolthoffi Jensen
Lycenchelys ingolfianus Jensen
Gymnelis viridis O. Fabricius
Bythites fuscus Reinhardt
Trachypterus arcticus Brünnich
Ceratias Holbölli Krøyer
Oneirodes Eschrichti Lütken
Himantolophus Reinhardti Lütken

On the Halibut in Icelandic Waters.

By

P. Jespersen.

During the years 1908—09, 1924 and 1925, a considerable material of halibut was procured by trawling in Faxe Bay, Iceland. The trawling experiments in 1908—09 were carried out by the marine research vessel »Thor«; those of 1924 and 1925 by the marine research vessel »Dana«. Furthermore, during the summer of 1925, halibut material was collected by the Scottish marine research vessel »Explorer«. The data from these last-named trawling experiments, with the otoliths of the captured halibut, were handed over by the Fishery Board for Scotland to Prof. Johs. Schmidt for treatment and this material is therefore included in the following report. The otoliths of all the halibut captured in these experiments in Faxe Bay during the respective years have been preserved, and it is therefore possible, from the material here available, to draw up a comparative survey of the composition of the halibut stock in the different years. The 1908—09 material has been dealt with in a previous publication [1]) and only that from 1924 and 1925 is therefore here subjected to closer consideration.

The present report comprises the following five points in connection with the biology of the halibut in Iceland waters.

I. Age determinations of halibut in Faxe Bay 1924 and 1925.
II. Average length and weight for the years 1908—09, 1924 and 1925.
III. No. of individuals of the different age-groups in the respective years.
IV. Comparison of the stock of halibut in intra- and extra-territorial waters (Faxe Bay 1924).
V. Investigations on the food of the halibut.

[1]) P. Jespersen: Contributions to the Life-History of the North Atlantic Halibut (Hippoglossus vulgaris Flem). Medd. fra Komm. for Havundersøgelser, Serie Fiskeri Bd. V, No. 5. Copenhagen 1917.

Age Determinations of Halibut in Faxe Bay 1924 and 1925.

cm	»Dana« 1924					cm	»Explorer« 1925			cm	»Dana« 1925			
	I	II	III	IV			II	III	IV		I	II	III	IV
85					1 (VIII)									
74					1 (VII)									
71					1 (VIII)									
65					1 (V)									
60				1	1 (V)	60				60				
									1					1
55				1		55			1	55				1
				1										
				2					1					
				2					1					
				2										
50				3		50			1	50				
				1										1
				2				1	1				1	
				4				1	2				2	
			4	3				1					2	1
45			3	1		45		1		45			1	2
			8	2				4	1				2	
			10					1					4	1
			18					5	2				1	
			18					5	1				5	1
40			20			40		5		40			9	1
			35	1				4					6	1
			40					6					9	1
			38					7					7	
			53					4					6	
35			34			35		4		35			11	
			34					1					8	
			19									2	7	
		2	12					1				1	1	
		5	4					4				2	1	
30		14	4			30	2	1		30		3	3	
		23	4				9	3				5	1	
		56	1				8					7		
		51					3					4		
		89					8					1		
25		91				25	8			25		1		
		114					3					1		
		108					5					1		
		94					2					1		
		65					1							
20		39				20	1			20				
		20												
		6												
		1									1			
											4			
15						15				15	1			
	1										7			
	5										7			
	10										18			
	8										18			
10	1					10				10	8			
											2			

I. Age determinations of halibut in Faxe Bay 1924 and 1925.

The material from the summer of 1924 was collected by the marine research vessel »Dana«; that from the summer of 1925 partly by the »Dana« and partly by the Scottish research vessel »Explorer«. The age determination was effected by means of the otoliths, extracted from the fish in a fresh state. Detailed information as to the age determination of halibut by means of otoliths will be found in JESPERSEN *loc. cit.* pp. 7—8.

The accompanying lists (p. 104) show the result of the age determinations for Faxe Bay, 1924 and 1925.

Calculating the average size of the year groups I—IV from the age determinations made, we obtain the following average lengths for the material from these two years.

Age Group	1924			1925		
	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation
I Group	25	**11.89**	10—14	66	**12.09**	9—18
II —	778	**24.14**	17—32	78	**26.96**	20—33
III —	359	**37.16**	28—46	140	**37.82**	29—48
IV —	26	**49.0**	39—60	23	**46.83**	38—57

Comparison of the material from these two years shows that the average lengths for the year-groups I, II and III are greater in 1925 than in 1924. This is especially the case in the II group, where the difference amounts to 2.82 cm. The available material of the IV group on the other hand is too slight to afford sufficiently accurate expression of the average figure.

The halibut were taken in these two years during the months of June, July and August. It appears that in the case of one of the year groups, we can form some idea as to the rate of growth in these summer months. The following table shows the calculated average lengths for the I, II and III groups, based on captures from different periods during the two years. The figures in parentheses indicate the number of specimens on which the average is based.

1924	Age Groups			1925	Age Groups		
	I	II	III		I	II	III
June 11.—12.	11.0 (5)	23.71 (80)	36.89 (18)	June 24.—26.	—	26.12 (50)	37.20 (59)
— 21.—27.	12.10 (20)	24.08 (601)	37.30 (261)	July 30.—Aug. 7.	12.09 (66)	28.46 (28)	37.55 (87)
July 6.—7.	—	24.73 (97)	36.74 (80)				

It will be observed that the II group in 1924 has grown 1.02 cm. from 11—12 June to 6—7 July, and 2.34 cm. from 24—26 June to 30 July—7 Au-

gust in 1925. In other words, the average length of the II group shows a summer increment of abt. 1.1—1.2 cm. in the course of a month in 1924, and 1.6—1.7 cm. per month in 1925. The average monthly increment is thus considerably greater in 1925 than in 1924, which agrees nicely with the fact that the average length of the II group is altogether considerably greater in 1925 than in 1924, viz. 26.96 as against 24.14 cm.

II. Average length and weight in 1908—09, 1924 and 1925.

A report on age determinations of halibut from Faxe Bay for the years 1908—09 has already been published (*l. c.* pp. 8—12); and it will be interesting therefore to compare this material with that of 1924 and 1925. The average lengths for the I—IV year groups will be seen from the table below:

Age Group	1908—09			1924			1925		
	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation
I ...	36	**10.1**	8-15	25	**11.89**	10-14	66	**12.09**	9—18
II ...	148	**23.5**	18—32	778	**24.14**	17—32	78	**26.96**	20—33
III ...	1469	**33.2**	21—48	359	**37.16**	28—46	146	**37.82**	29—48
IV ...	148	**46.6**	30—62	26	**49.0**	39—60	23	**46.83**	38—57

From this it will be seen that the average size for these four groups of halibut is considerably greater in 1924 and 1925 than in 1908—09.

Furthermore, on calculating the average weights for the different years, it will be found that this — like the average length — is considerably greater for the last two years than for 1908—09. As the weight varies quite considerably within the individual year groups, a fairly large amount of material is needed to give a reliable average. We will therefore only consider here the average weights of the II and III groups.

Age Group	1908-09		1924		1925	
	No. of specimens	Average weight	No. of specimens	Average weight	No. of specimens	Average weight
II	40	**130**	200	**151**	29	**211**
III	530	**400**	148	**619**	96	**574**

III. No. of individuals of the age-groups in the respective years.

In seeking to form an impression as to the numbers in which the different year-groups are represented in the halibut material from Faxe Bay, it is

only worth while considering groups I—IV, the older groups having been taken only in very small numbers. The following table shows the no. of specimens in these four groups for the years 1908—09, 1924 and 1925, and it will be noted that the relative numbers of the individual groups vary greatly in the different years.

Age Group	1908—09		1924		1925	
	No. of specimens	%	No. of specimens	%	No. of specimens	%
I	36	2.0	25	2.1	66	21.2
II	148	8.2	778	65.5	78	24.9
III	1469	81.6	359	30.2	146	46.6
IV	148	8.2	26	2.2	23	7.3

In 1908—09, the III group is numerically predominant, in 1924, the II group, and in 1925, the III group. Particularly noticeable is the high numerical proportion of the III group in the 1908—09 material. Group I again, was proportionately far more richly represented in 1925 than in the other years.

It is particularly interesting to compare the 1924 material with that of 1925, these being two successive years. In 1924, the II group, i. e. that of fish spawned in 1922, is numerically predominant. The year 1922 must therefore be regarded as a specially favourable year for the spawning of halibut. In agreement with this, we find the corresponding year-group in 1925 (here the III group) again predominant in numbers. This predominance of the 1922 year-class of halibut in the 1924 and 1925 material is further illustrated by the accompanying table, showing the numbers of the 1921, 1922 and 1923 year-classes during these two years.

Year class	1924			1925		
	Age group	No. of specimens	%	Age group	No. of specimens	%
1921	III	359	30.9	IV	23	9.3
1922	II	778	67.0	III	146	59.1
1923	I	25	2.1	II	78	31.6

IV. Comparison of the stock of halibut in intra- and extra-territorial waters. (Faxe Bay 1924.)

During the summer of 1924, a series of trawling experiments was carried out in Faxe Bay with a view to determining the difference in quantity and composition of the stock of fish of different species within and beyond the ter-

ritorial limit. In the following, comparison is made with regard to the halibut between trawl catches made in intra- and extra-territorial waters. As the quantities of halibut taken by trawling in Faxe Bay are but small compared with the plaice for instance, it is somewhat difficult to obtain any reliable view of the conditions with regard to this species. The results of these trawling experiments in the summer of 1924 can therefore only be considered as a preliminary attempt at elucidation of the question as to difference in quantity of the halibut within and beyond the territorial limit. In 1925, the experiments were repeated, but this time, the number of halibut captured was insufficient to afford material for comparison, and we shall therefore only consider the 1924 material.

In the summer of 1924, trawling experiments were made in Faxe Bay covering a period of 32.75 hours inside, and 51 hours outside the territorial limit. On calculating the average number of halibut taken per trawling hour, we find the figures 18.2 inside and 9.7 outside the territorial limit. These figures show that the relative number of halibut inside the territorial limit in Faxe Bay is nearly twice that found outside.

Expressed in terms of weight, the difference between the two areas is even more pronounced. Inside the territorial limit, we have 5.58 kilos of halibut taken per trawling hour, whereas the catch outside amounted to only 1.75 kilos per trawling hour.

Expressed in weight, then, the amount of halibut taken inside the territorial limit is more than three times that caught outside.

On calculating the average lengths of the fish, we find 29.92 cm. intra-territorial and 26.24 cm. extra-territorial. The difference is thus 3.68 cm. It will be found interesting however, to look a little more closely at the sizes of fish in these two areas. Grouping the lengths for each area at intervals of 5 cm., and calculating the percentage of halibut falling to each group, we obtain

cm	Intra-territorial waters		Extra-territorial waters	
	No. of specimens	%	No. of specimens	%
>50	14	2.01	3	0.60
45—49	12	1.73	6	1.21
40—44	49	7.04	27	5.43
35—39	152	21.84	49	9.86
30—34	65	9.34	29	5.83
25—29	166	23.85	149	29.98
20—24	224	32.18	196	39.44
15—19	14	2.01	13	2.62
10—14	—	—	25	5.03

directly comparable material. The table p. 108 shows the numbers of halibut and percentage falling to the different size groups; the accompanying graph (Fig. 56) shows the percentages for both intra- and extra-territorial waters.

It will be seen from the curves that both inside and outside the territorial limit, the same size groups predominate. There is, however, this difference:

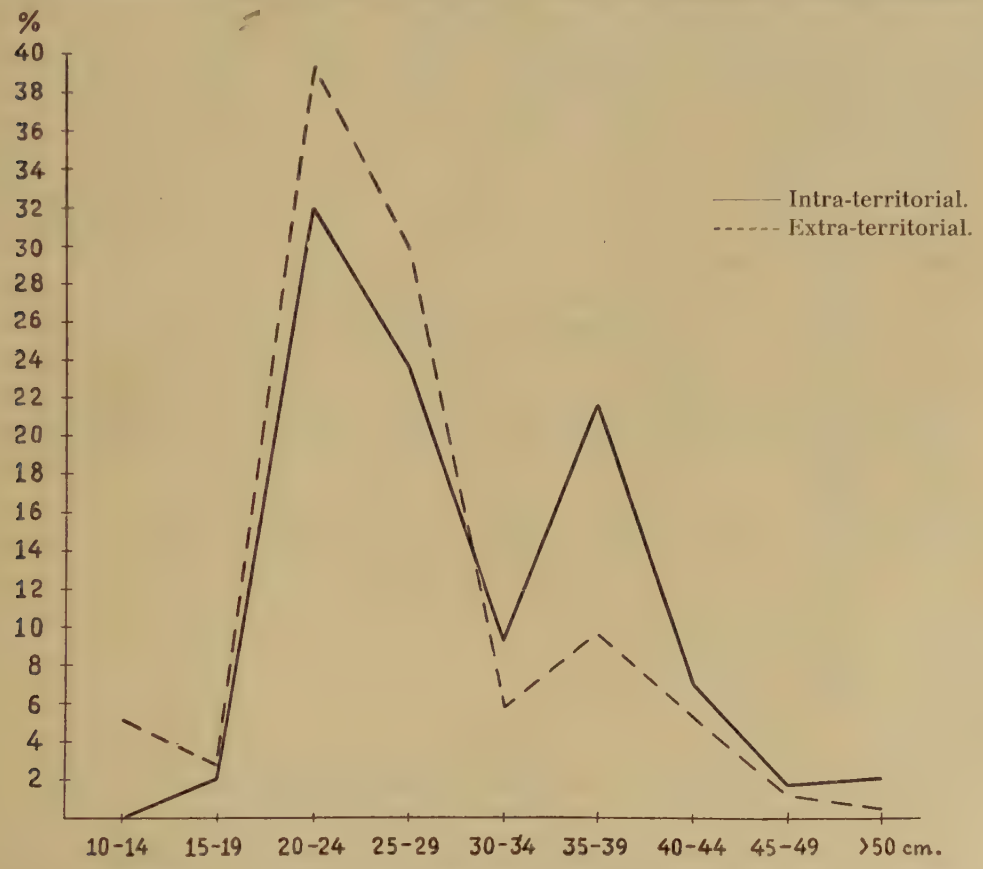

Fig. 56. Percentage of the different size groups of halibut inside and outside the territorial limit. Faxe Bay 1924.

that the larger groups (30—45 cm.) are far more richly represented in the catches made within the territorial limit than in those from outside, and it is this which gives the great difference in average size for the two areas.

Otoliths were taken from all the halibut caught in these trawling experiments in Faxe Bay, and it has therefore been possible to make age determinations of the whole available material. From the intra-territorial waters we have age determinations of a total of 696 halibut, and from the waters outside, 497.

Calculating the average lengths for the different year groups from these

age determinations, we obtain the figures given below (p. 111), from which it will be seen that there is no demonstrable difference in the average size of the respective year groups within and beyond the territorial limit.

It is interesting now to consider how the different year groups are repres-

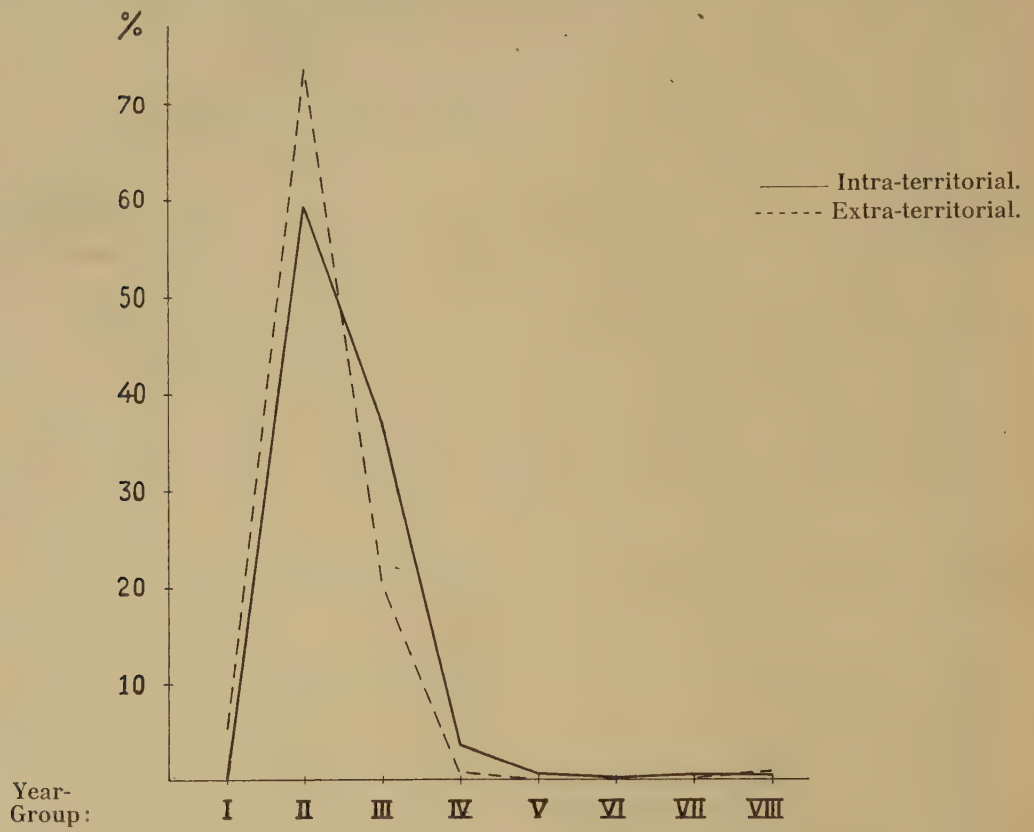

Fig. 57. Relative quantity of the different year groups of halibut inside and outside the territorial limit. Faxe Bay 1924.

ented in the material from the two areas. We have accordingly shown, in the table below (p. 111), the relative quantities of halibut of the different year groups in the respective areas. The percentages are shown graphically in the accompanying figure (Fig. 57).

It will be noticed that the II group predominates in both areas, but that the older specimens (> II group) are relatively far more richly represented in the intra-territorial material than in the extra-territorial. This agrees well with the fact already noted in the foregoing, that there are relatively more halibut of 30—45 cm. inside than outside the territorial limit. It is also interesting to note that all specimens of the I group were taken outside the territorial limit.

	Intra-territorial waters								
	♂			♀			♂ + ♀		
	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation
I..	—	—	—	—	—	—	—	—	—
II..	215	**23.78**	18—31	126	**24.56**	18—32	412	**24.19**	18—32
III..	121	**36.78**	28 - 46	122	**37.13**	30—45	258	**37.02**	28—46
IV..	10	**46.40**	39—53	9	**49.78**	46—55	22	**48.50**	39—55
V..	1	**59.0**	59	1	**65.0**	65	2	**62.0**	59—65
VI..	—	—	—	—	—	—	—	—	—
VII..	1	**74.0**	74	—	—	—	1	**74.0**	—
VIII..	—	—	—	1	**71.0**	71	1	**71.0**	—

	Extra-territorial waters								
	♂			♀			♂ + ♀		
	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation	No. of specimens	Average length	Range of variation
I..	—	—	—	—	—	—	25	**11.89**	10—14
II..	188	**24.18**	18 - 31	142	**24.16**	17—31	366	**24.07**	17—31
III..	46	**37.26**	29—45	54	**37.94**	31—46	101	**37.51**	29—46
IV..	2	**56.50**	53—60	2	**47.0**	47	4	**51.75**	47—60
V..	—	—	—	—	—	—	—	—	—
VI..	—	—	—	—	—	—	—	—	—
VII..	—	—	—	—	—	—	—	—	—
VIII..	1	**85.0**	85	—	—	—	1	**85.0**	—

The explanation of this phenomenon must presumably lie in the fact that the halibut, as we know, spawns in water of great depth, and that its post-larval stages are also found there.

Age group	Intra-territorial waters		Extra-territorial waters	
	No.	%	No.	%
I	—	—	25	**5.03**
II	412	**59.20**	366	**73.64**
III	258	**37.07**	101	**20.32**
IV	22	**3.16**	4	**0.81**
V	2	**0.29**	—	—
VI	—	—	—	—
VII	1	**0.14**	—	—
VIII	1	**0.14**	1	**0.20**

V. Investigations on the food of the halibut.

We have records of the stomach contents of some two hundred halibut from Faxe Bay, taken in June 1924. These investigations were made on board, at the same time as the fish were being measured and weighed, the sex determined, and the otoliths removed; there was therefore no opportunity for detailed analysis of the stomach contents, or specific determination for instance of the various crustacea there found. The data available, however comprising a total of 204 halibut, present various features of interest, and we will therefore give a brief account of the investigations.

The following table shows the material divided into groups according to total length, at 5 cm. intervals. For each of these groups, we have noted the total number of specimens investigated, and the percentage of halibut found with polychæta, molluscs, crustacea and fish in the stomach [1]).

Length	No. of halibut investigated	Polychæta		Crustacea		Mollusca		Pisces	
		No.	%	No.	%	No.	%	No.	%
40—46 cm.	21	—	—	7	33.3	—	—	19	90.5
35—39 - .	41	—	—	4	9.8	—	—	39	95.1
30—34 - .	16	—	—	7	43.7	—	—	12	75.0
25—29 - .	50	—	—	34	68.0	—	—	25	50.0
19—24 - .	76	1	1.3	72	94.7	1	1.3	11	14.5

It will be seen that halibut at these lengths live practically speaking, exclusively on crustacea and fish. It will be noted however, that the smaller specimens live mainly on crustacea the larger ones to a far greater extent on fish. The fish food consists almost entirely of Ammodytes, only a single Triglops having been found in one specimen (of 23 cm. length) whereas all the rest consisted of Ammodytes.

As the lengths 19—30 cm. comprise specimens of the II group, and those from 30—46 cm. belong to the III group, the stomach analyses for the two year groups give the following result:

Age-Group	No. of halibut investigated	Polychæta		Crustacea		Mollusca		Pisces	
		No.	%	No.	%	No.	%	No.	%
III.....	78	—	—	18	23.1	—	—	70	89.7
II.....	126	1	0.8	106	84.1	1	0.8	36	30.2

The II group of halibut in Faxe Bay thus seeks its food mainly among the crustacea, whereas the III group lives on crustacea to some slight extent,

[1]) The calculations are based throughout on number of halibut with stomach content.

but altogether predominantly on Ammodytes. Among the crustacea, we find especially paguridæ, Crangon and mysids, as a frequently occuring food item in the halibut; but with regard to crustacea generally it may be said that they are far more frequent as food for the II group than for the III group. These facts are very distinctly apparent from the following table, showing the percentage of halibut found to contain the various crustacea as food.

Age-Group	Crabs (Carcinus?)		Hyas		Galathea		Paguridæ		Crangon		Spirontocaris		Pandalus		Mysidæ	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
III.	—	—	8	10.3	—	—	5	6.4	4	5.1	1	1.3	3	3.8	1	1.3
II.	4	3.2	9	7.1	2	1.6	47	37.3	45	35.7	1	0.8	10	7.9	32	25.4

Investigations on Icelandic Herrings in 1924 and 1925.

By

A. C. Johansen.

Fig. 58. Iceland.

I. Introduction.

During the years 1924 and 1925, analyses of Icelandic Herrings were made from the following localities:

1) Selvog's Bank (South-west Iceland)
2) Fuglasker »
3) Kögur Huk (North-west Iceland)
4) E. of Malmey, Skagafjord (North Iceland)
5) Off Eyjafjord (North Iceland).

The herrings from the three first-mentioned localities were procured at the instigation of Hr. Fiskerikonsulent Bjarni Sæmundsson, of Reykjavik, those from the last two being placed at our disposal by Dr. Johs. Schmidt. The fish were examined in a salted state. Practically all were adult specimens, the degrees of maturity varying from III—VIII [1]).

II. Analyses.

From Selvog's Bank we have the following material of spring-spawning herring, all taken in the trawl:

1) 30 specimens.	25 February 1924.	
	Maturity V	3 specimens.
	» V—VI	27 »
2) 2 specimens.	15 March 1924.	
	Maturity V—VI	1 specimen.
	» VII	1 »
3) 1 specimen.	3 April 1924.	
	Maturity VI—VII	1 »
4) 13 specimens.	20 April 1924.	
	Maturity VI	13 specimens.
5) 5 specimens.	30 April 1924.	
	Maturity V—VI	1 specimen.
	» VI—VII	2 »
	» VII	2 »
6) 34 specimens.	15 February 1925.	
	Maturity V—VI	34 specimens.
7) 30 specimens.	15 April 1925.	
	Maturity VI	abt. 5 specimens.
	» VII	» 25 »

It will be seen from the above that none of the specimens examined in February had begun spawning whereas one of those from March had spawned. About half those from April were fully mature, and the other half had spawned.

It is thus evident that the Icelandic Spring Herring spawn at least during the months of March and April. From the scanty material here available it would seem as if most of the spawning took place in April.

Biometrical analyses were made of 85 specimens from among these taken at Selvog's Bank. The lengths were as follows.

[1]) Cf. A. C. Johansen 1924 p. 4.

Length cm	26	27	28	29	30	31	32	33	34	35	36	37	38	No of spec.	Average length cm
♂	1	3	8	2	5	6	1	4	1	4	2	3	2	42	31.48+0.5
♀		2	2	5	5	3		6	3	6	6	5		43	32.77+0.5
♂+♀	1	5	10	7	10	9	1	10	4	10	8	8	2	85	32.13+0 5

Age determinations were made in 47 cases, with the following result:

Table 1.

Age and Length of spring-spawning Herrings of Maturity V—VII. Selvog's Bank, S. W. Iceland. Spring of 1924.

Length cm		27	28	29	30	31	32	33	34	35	36	37	38	Total No. of spec.	Average Length cm	Corrected by 0.5
Year class	No. of Winter-rings															
1920	4	1.	1			2								4	29.25	29.75
1919	5					1		1						2	32.0	32.5
1918	6				1		1	5	1	1				9	32.89	33.39
1917	7							2	2	2	1	1		8	34.63	35.13
1916	8								1	2	3			6	35.33	35.83
1915	9									1	2	2	1	6	36.5	37.0
1914	10									2		2		4	36.0	36.5
1913	11									1	2	1	1	5	36.40	36.9
1912	12											1		1	37.0	37.5
	4—5			1										1	29.0	29.5
	5—6		1											1	28.0	28.5
Total No. of spec.		1	2	1	1	3	1	8	4	9	8	7	2	47		

It will be seen that specimens of 6 years age have an average length of about 33 cm, and specimens of 10 years age an average length of about 37 cm.

The distribution of the variants for the individually constant characters examined was as follows:

Vert. S.		Vert. præc.		Vert. caud.		K_2	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	1	23	9	31	3	12	5
56	5	24	37	32	17	13	24
57	34	25	30	33	39	14	42
58	40	26	8	34	23	15	10
59	4			35	2		
n	84		84		84		81
m	57.49		24.44		33.05		13.70
σ	0.74		0.81		0.85		0.77
σ_m	0.08		0.09		0.09		0.09
σ_σ	0.06		0.06		0.06		0.06

Rays in ventral fins		Branched Rays dorsal fin		Rays in anal fin Total		branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
17	5	14	9	16	1	13	3	3	46
18	70	15	38	17	19	14	26	4	18
19	2	16	15	18	30	15	27		
				19	13	16	8		
				20	1				
n	77		62		64		64		64
m	17.96		15.10		17.91		14.62		3.28
σ	0.30		0.62		0.79		0.77		0.45
σ_m	0.03		0.08		0.10		0.10		0.06
σ_σ	0.02		0.06		0.07		0.07		0.04

This sample is of particular interest, as being the first instance in which the fully mature Icelandic Spring Herring have been subjected to biometrical investigation. The result shows that the no. of vertebræ is abt. 57,50 or precisely the same as in the Norwegian Spring Herring, but abt. 0.5 above the corresponding figure for the Icelandic Summer Herring and Scottish Spring Herring[1]). The difference in no. of vertebræ between Icelandic Spring Herring and Icelandic Summer Herring arises from the caudal vertebræ, the number of præcaudal vertebræ being, if anything, higher in the summer herring than in the spring-spawning fish. The other characters investigated hardly show any constant difference between spring and summer herring; it seems however, that the spring herring have as a rule a higher number of keeled scales than the summer herring.

From Fuglasker we have a small sample of 13 herring taken in drift nets on the 14 September 1924 (See Table B). The degree of maturity was III and IV in 12 of these, so that they must be reckoned as spring-spawning fish.

The lengths of the spring herring were as follows:

Length cm	28	29	30	31	32	No. of spec
♂	2	0	2	2	1	7
♀			4		1	5

The age of the specimens varied from 4—6 years.

Counting of vertebræ and keeled scales etc. gave the following results:

Vert. S.		Vert. præc.		Vert. caud.		K_2	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
57	5	24	7	33	9	13	6
58	6	25	4	34	2	14	4
						15	2
n	11		11		11		12
m	57.55		24.36		33.18		13.67

[1]) cf. A. C. Johansen: 1919, 1921, 1924.

Rays in ventral fins		Total		Rays in anal fin branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
17	2	16	1	13	1	2	1
18	9	17	3	14	3	3	8
		18	5	15	7	4	3
		19	3	16	1		
n	11		12		12		12
m	17.82		17.83		14.67		3.17

It will be noted that these fish are very like the samples from Selvog's Bank. One of the specimens examined showed maturity VII and thus belongs to the summer-spawning fish.

From Kögur Huk, in North-west Iceland, we have a sample of 49 adult herring taken in purse seine on the 6th September 1924 (see Table C). This sample contained 37 specimens of maturity VII—VIII and 12 whose maturity was uncertain, probably III or IV. The 37 were summer-spawning fish, the 12 mainly spring-spawning. The lengths of the 37 summer-spawning herring were as follows:

Length cm	33	34	35	36	37	No. of spec.	Average length cm
♂	1	4	7	5	4	21	35.33 + 0.5
♀		2	6	5	3	16	35.56 + 0.5
♂ + ♀	1	6	13	10	7	37	35.43 + 0.5

As will be seen from the table below, most of the fish had abt 7—10 winter-rings in the scales.

Table 2.

Age and Length of summer-spawning Herrings of Maturity VII—VIII. Kögur Huk. N. W. Iceland. 6 September 1924.

Length cm		33	34	35	36	37	Total No. of spec.	Average Length cm	Corrected by 0.5
Year class	No. of Winter-rings								
1918	5	1					1	33.0	33.5
1917	6		1	1			2	34.5	35.0
1916	7		2	6	3		11	35.09	35.59
1915	8		2	1	2	2	7	35.57	36.07
1914	9			4	3	3	10	35.90	36.40
1913	10				2	1	3	36.33	36.83
1912	11		1			1	2	35.5	36.0
1911	12			1			1	35.0	35.5
Total No. of specimens		1	6	13	10	7	37		

The average length of specimens of 10 years age was between 36 and 37 cm.

The number of vertebræ and fin rays etc. was as follows:

Vert. S. No.	Vert. S. Freq.	Vert. præc. No.	Vert. præc. Freq.	Vert. caud. No.	Vert. caud. Freq.	K_2 No.	K_2 Freq.
56	5	23	1	30	3	12	2
57	23	24	13	31	9	13	14
58	8	25	9	32	10	14	19
		26	10	33	12	15	2
		27	2	34	2		
		28	1				
n	36		36		36		37
m	57.08		25.06		32.03		13.57

Rays in ventral fins No.	Freq.	Rays in anal fin Total No.	Total Freq.	branched No.	branched Freq.	unbranched No.	unbranched Freq.
16	4	17	7	14	12	3	27
17	2	18	17	15	15	4	8
18	29	19	11	16	8		
19	0						
20	2						
n	37		35		35		35
m	17.84		18.11		14.89		3.23

The sample agrees with previously investigated samples of the Icelandic Summer Herring from Eldey and Drangar in South-west Iceland (A. C. Johansen 1921). As the Icelandic Summer Herring presumably do not spawn in the west Icelandic waters so far north as Kögur, the fish must have moved northwards after spawning.

From Malmey in the Skagafjord we have 187 fat herring, maturity III—IV. These fish were taken in purse seine on the 22 July 1924.

43 specimens were examined for state of maturity shortly after capture. The examination was made by A. Fr. Bruun, and gave the following result:

Length cm	Mat. III ♂	Mat. III ♀	Mat. IV ♂	Total ♂ + ♀
30		1		1
31	1			1
32		3	1	4
33	1	3	1	5
34	4	3	4	11
35	3	3	2	8
36		4	4	8
37		4	1	5
	9	21	13	43

The remainder of the sample was salted down, and further investigated later on. (See Table D). The total lengths of 144 specimens were as follows:

Length cm	30	31	32	33	34	35	36	37	38	Average length cm
♂ + ♀	1	9	16	31	56	19	7	4	1	33.69 + 0.5

The distribution of the variants for the individually constant characters examined was as follows:

Vert. S.		Vert. præc.		Vert. caud.		K_2	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	13	22	1	31	6	12	2
57	61	23	14	32	38	13	31
58	56	24	56	33	62	14	84
59	13	25	55	34	31	15	17
		26	14	35	6	16	2
		27	3				
n	143		143		143		136
m	57.48		24.53		32.95		13.90
σ	0.79		0.90		0.72		0.68
m	0.07		0.08		0.06		0.06
σ_σ	0.05		0.05		0.04		0.04

Rays in ventral fins		Rays in anal fin					
		Total		branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
16	1	16	2	13	5	3	93
17	1	17	12	14	22	4	44
18	55	18	60	15	66		
		19	46	16	36		
		20	17	17	8		
n	57		137		137		137
m	17.95		18.47		15.15		3.32
σ	0.29		0.88		0.89		0.47
σ_m	0 04		0.07		0.08		0.04
σ_σ	0.03		0.05		0.04		0.03

The sample in question must, to judge by the degree of maturity, consist of spring-spawning fish. Comparison with the spring spawning herring from Selvog's Bank gives the following result:

84 spring spawners from Selvog's Bank 1924/25 minus 143 spring spawners, Malmey, 22—7—1924:

Diff. Vert. S.	+ 0.01	standard deviation of diff.		0.11
— — præc.	— 0.09	—	—	0.12
— — caud.	+ 0.10	—	—	0.11
— K_2	— 0.20	—	—	0.11
— rays in ventr. fins	+ 0.01	—	—	0.05
— — anal fin	— 0.56	—	—	0.11

A difference is here apparent in the no. of anal fin rays, whereas the remaining characters agree well enough.

From the waters outside Eyjafjord (abt. 66° 11′ N., 18° 25′ W) we have a sample of 166 herring taken in drift nets on the 12 September 1924 (See Table E.). The maturity of these was as follows:

Maturity IV and IV—V	49	specimens
— VIII	47	—
— III or VIII	69	—
— II	1	—

The first of these groups represents spring-spawning herring, the second one summer-spawners; it was impossible to determine, by examination of the degree of maturity, to which of these groups the 69 specimens noted as III or VIII belong.

The sizes of the 49 spring herring of maturity IV and IV—V were as follows:

Length cm	31	32	33	34	35	36	37	No. of spec.	Average length cm
♂	1		1	8	10	15	6	41	35.32 + 0.5
♀				1	3	1	3	8	35.75 + 0.5
♂ + ♀	1		1	9	13	16	9	49	35.39 + 0.5

Age determinations gave the following result:

Table 3.

Age and Length of spring-spawning Herrings of Maturity IV—V from the North of Iceland off Eyjafjord. 12 Sept. 1924.

Length cm		31	32	33	34	35	36	37	Total No. of spec.	Average Length cm	Corrected by 0.5
Year class	No. of Winter-rings										
1919	5						1		1	36.0	36.5
1918	6	1			1	1	2		5	34.4	34.9
1917	7				1	5	3	2	11	35.55	36.05
1916	8				1	2	5	2	10	35.80	36.30
1915	9				2	2	2	1	7	35.29	35.79
1914	10				3	2	2	4	11	35.64	36.14
1913	11				1	1	1		3	35.0	35.5
Total No. of spec.		1			9	13	16	9	48		

It appears that specimens of 8—10 years age have an average length of about 36 cm.

The distribution of the variants for vertebræ and fin rays etc. was as follows:

Vert. S.		Vert. præc.		Vert. caud.		K_2		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	1	23	5	32	12	11	1	17	1
57	24	24	22	33	21	12	1	18	47
58	23	25	20	34	15	13	15	19	1
59	1	26	2	35	1	14	21		
						15	10		
n	49		49		49		48		49
m	57.49		24 39		33.10		13.79		18.00
σ	0.58		0.73		0.80		0.87		0.20
σ_m	0.08		0.10		0.11		0 13		0.03
σ_σ	0.06		0.07		0.08		0.09		0.02

Rays in dorsal fin				Rays in anal fin			
branched		Total		branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
14	6	17	5	14	8	3	35
15	26	18	24	15	25	4	13
16	15	19	13	16	15		
		20	6				
n	47		48		48		48
m	15 19		18.42		15.15		3.27
σ	0 65		0.85		0.68		0.45
σ_m	0.09		0.12		0.10		0.06
σ_σ	0.07		0.09		0.07		0.05

It will be noted that this sample closely resembles that from Malmey, but that it has, like the Malmey sample, a somewhat higher number of anal fin rays than the spring herring from Selvog's Bank.

The lengths of the 47 summer spawners of maturity VIII were as follows:

Length cm	34	35	36	37	38	No. of spec.	Average length cm
♂	3	9	6	5	1	24	35.67 + 0.5
♀	3	3	12	4	1	23	35.87 + 0.5
♂ + ♀	6	12	18	9	2	47	35.77 + 0.5

Age determination gave the following result:

Table 4.

Age and Length of summer-spawning Herrings from the North of Iceland off Eyjafjord. 12 September 1924.

Length cm		34	35	36	37	38	Total No. of spec.	Average length cm	Corrected by 0.5
Year class	No. of Winter-rings								
1918	5		1				1	35.0	35.5
1917	6	3		3	1		7	35.29	35.79
1916	7	2	4	3	1		10	35.40	35.90
1915	8	1	4	5	4		14	35.86	36.36
1914	9		2	3		1	6	36.0	36.5
1913	10		1	4	3		8	36.25	36.75
1911	12					1	1	38.0	38.5
Total No. of specimens		6	12	18	9	2	47		

It will be seen that specimens of 10 years age have an average length of between 36 and 37 cm. Most of the specimens — if not all — have, according to their age, spawned more than once.

The distribution of the individually constant characters examined was as follows:

Vert. S.		Vert. præc.		Vert. caud.		K_2		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	9	22	1	29	1	12	1	16	3
57	30	23	4	30		13	18	17	2
58	8	24	20	31	6	14	23	18	39
		25	18	32	13	15	5	19	3
		26	3	33	21				
		28	1	34	6				
n	47		47		47		47		47
m	56.98		24 47		32.51		13.68		17.89
σ	0.61		0.97		1.02		0.69		0.60
σ_m	0.09		0.14		0.15		0.10		0.09
σ_s	0.06		0.10		0.10		0.07		0.06

Rays in dorsal fin		Rays in anal fin					
branched		Total		branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
14	1	16	1	13	1	3	36
15	26	17	4	14	7	4	11
16	18	18	21	15	23		
17	2	19	17	16	15		
		20	4	17	1		
n	47		47		47		47

	Rays in dorsal fin		Rays in anal fin	
	branched	Total	branched	unbranched
m	15.45	18.40	15.17	3.23
σ	0.62	0.85	0.79	0.43
σ_m	0.09	0.12	0.12	0.06
σ_σ	0.06	0.09	0.09	0.04

The sample agrees well with previously investigated samples of the Icelandic Summer Herring from Eldey Bank and Drangar in South-west Iceland (A. C. Johansen 1921). A comparison gives the following result:

477 Summer Herrings Eldey Bank and Drangar 1921, minus 47 Summer Herrings, Eyjafjord, Sept. 12. 1924:

Diff. Vert. S.	+ 0.07	Standard dev. of Diff.		0.10
— — præc.	+ 0.21	—	—	0.15
— — caud.	— 0.14	—	—	0.16
— K_2	— 0.10	—	—	0.11
— Rays in ventr. fins	+ 0.02	—	—	0.10
— Branch. rays in dors. fin	— 0.08	—	—	0 09
— Total rays in anal fin	— 0.35	—	—	0.13

The greatest difference noted lies in the no. of anal fin rays, but the difference is less than three times the standard deviation of difference.

Individuals of maturity III or VIII showed lengths as follows:

Length cm	33	34	35	36	37	38	No. of spec.	Aver. length cm
♂	1	1	4	10	5		21	35.81 + 0.5
♀	2	11	10	15	9	1	48	35 23 + 0.5
♂ + ♀	3	12	14	25	14	1	69	35.55 + 0 5

Age determinations gave the following result:

Table 5.

Age and Length of mixed Herrings (of maturity III and VIII) from the North of Iceland off Eyjafjord. 12 September 1924.

Length cm	33	34	35	36	37	38	Total No. of spec.	Average length cm	Corrected by 0.5
No. of Winter-rings									
6	2	2	1	1	1		7	34.57	35.07
7		4	6	3	1		14	35.07	35.57
8	1	3	2	10	6		22	35.77	36.27
9		1	2	3	3		9	35.89	36.39
10			2	6	3		11	36.09	36.59
11		1		1		1	3	36.0	36.5
13		1	1	1			3	35.0	35.5
Total No. of spec.	3	12	14	25	14	1	69		

The distribution of the variants for vertebræ and fin rays etc. was as follows:

Vert S.		Vert. præc.		Vert. caud.		K_2		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	7	23	5	31	5	12	2	16	2
57	41	24	26	32	27	13	19	17	5
58	21	25	33	33	26	14	42	18	61
		26	4	34	10	15	5	19	
		27	1	35	1			20	1
n	69		69		69		68		69
m	57.20		24.57		32.64		13.75		17.90
σ	0.61		0.78		0 87		0.64		0.49
σ_m	0.07		0.09		0.11		0.08		0.06
σ_σ	0.05		0.07		0.07		0.06		0.05

Rays in dorsal fin		Rays in anal fin: Total		branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
14	7	17	10	13	2	2	1
15	41	18	32	14	14	3	51
16	19	19	21	15	31	4	16
17	1	20	4	16	17		
		21	1	17	4		
n	68		68		68		68
m	15.21		18.32		15.16		3.22
σ	0.64		0.85		0.90		0.45
σ_m	0.08		0.10		0.11		0.05
σ_σ	0.06		0.07		0.08		0.04

The result of the analysis shows with pretty fair certainty that we have here to deal with mixed herring. The sample evidently contains both specimens of maturity III (Spring herring) and specimens of maturity VIII (Summer spawners). The latter have probably been in the majority.

The sample from the waters outside Eyjafjord is of great importance, inasmuch as it shows that the Icelandic Summer Herring, after spawning in the waters of the South and South-west Iceland move, at any rate to a certain extent, round to the North Icelandic waters[1]).

It is interesting to note in this connection that the majority of the specimens from Kögur Huk in the north-west (6. Sept. 1924) consisted of summer-spawning fish of maturity VII—VIII (see p. 118).

[1]) P. Jespersen has shown (1920) that the larvæ of the summer-spawning herring drift with the current from the southern and south-western waters northward round Iceland, in a similar manner to the larvæ of the spring-spawning herring (Johs. Schmidt 1904; Bj. Sæmundsson 1908).

It can now be determined with a fair degree of certainty that some of the fish in a sample from North Iceland, outside Eyjafjord, Sept. 1915, previously investigated by me[1]), were likewise summer spawners. — Out of 100 specimens investigated, 31 were noted as maturity VIII (recovering spents), and analysis of these gave the following result:

Vert. S.		Vert. præc.		Vert. caud.		K_2		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	5	22	1	30	1	12	1	16	2
57	21	23	2	31	3	13	10	17	2
58	5	24	16	32	10	14	14	18	23
		25	7	33	12	15	5	19	3
		26	4	34	5	16	1	20	1
		27	1						
n	31		31		31		31		31
m	57.00		24.45		32.55		13.84		17.97

This sample probably consisted exclusively or mainly of summer-spawning fish. The no. of vertebræ found was normal for this class, and though the no. of keeled scales and ventral fin rays is somewhat higher than is generally found in summer-spawners, it must be born in mind that the sample consists of relatively few specimens, and that the difference between the value found and the normal number is not more than once or twice the mean error of the difference.

III. Main Results of the Investigations in 1924 and 1925.

In 1924, the first biometrical analyses of fully mature Icelandic spring herring were made, so that confusion with summer spawning fish was out of the question. The samples investigated, however, were small. The no. of vertebræ, for instance, was only investigated in 84 specimens, and the no. of keeled scales and fin rays only in 62—81 specimens. The investigation has confirmed the result I arrived at in 1919: that there is no known character by which we can distinguish between the Icelandic Spring Herring and the Norwegian Spring Herring. The Icelandic Spring Herring do, however, seem to have usually a somewhat lower figure for no. of keeled scales (K_2) than the Norwegian Spring Herring, but this character is subject to such a considerable degree of variation that it can not be used as a sure distinguishing mark.

The investigations made with Icelandic Spring Herring have shown that these fish have precisely the same no. of vertebræ as the Norwegian Spring Herring, namely 57.50. The analyses from the different localities gave the following results:

[1]) A. C. Johansen (1919).

Locality	Date	No. of spec.	Aver. No. of vertebrae
Selvog's Bank, S. W. Iceland	Spring of 1924 and 1925	84	57.49 ± 0.08
Fuglasker, — —	Sept. 14. 1924	11	57.55
Malmey, N. —	July 22. —	143	57.48 ± 0.07
Off Eyjafjord, — —	Sept. 12. —	49	57.49 ± 0.08

The samples of spring-spawning fish from North Iceland had a slightly higher no. of anal fin rays than the samples from the south-west coast. The difference was abt. 0.5. It is not likely that the difference found indicates the existence of more than one race of spring-spawning sea herring off the coasts of Iceland. In the great spawning region of the Icelandic Spring Herring on the south and south-west coasts of Iceland there is perhaps some variation in the mean value for the mentioned character, and minor variations may also occur in the same locality from one year to another (A. C. Johansen 1921). The spawning season for the Icelandic Spring Herring covers at least the months of March and April.

The investigations have shown that adult spring-spawning herring can be taken off the south-west coast of Iceland in September, i. e. at the time when they are also extremely numerous in the northern waters.

The analyses have proved that the Summer-Spawning Icelandic Herring, after spawning in the waters of the south and south-west in July—August, move round to the northern waters, and may be found there as early as September. A sample from North Iceland, outside Eyjafjord, taken on the 12 September 1924 (166 specimens in all) contained at least as many summer-spawning as spring-spawning fish. It can now be shown that a sample of 192 specimens previously investigated in September 1915, from North Iceland, outside Eyjafjord (A. C. Johansen 1919) also contained summer spawning herring, (Maturity VIII) but these were in the minority in that sample (abt. 30 %). A sample of 210 specimens from North Iceland September 1909, examined by E. Lea, undoubtedly also contained both summer- and spring-spawning fish, and from Lea's maturity determinations it must be assumed that about half the fish were summer spawners. (Lea's maturity groups 2 and 2—3 here doubtless correspond to my class VIII).

The total no. of vertebræ in the summer herring of Icelandic waters is very nearly 57.00 as will bee seen from the following survey:

Locality	Date	No. of spec.	Average number of vertebrae
Eldey Bank, S. W. Iceland	14 May 1919	297	57.07 ± 0.038
Drangar, — —	14 Aug. —	180	57.01 ± 0.048
Kögur Huk, N. W. —	6 Sept. 1924	36	57.08
Off Eyjafjord, N. —	Sept. 1915	31	57.00
— — — —	12 — 1924	47	56.98 ± 0.09

The Icelandic Summer Herring have the same number of vertebræ as the Scottish Spring Herring, and are altogether closely akin to this form (cf. A. C. Johansen 1924).

Tables of the Analyses of Herrings caught in Icelandic Waters 1924 and 1925.

A. Herrings from Selvog's Bank.

Caught by Trawl in spring of 1924 and 1925.

No.	Length cm	Sex	Maturity	Vertebrae			Keeled scales K_2	Branched Rays in Dorsal fin	Rays in Anal fin [1]	Rays in ventral fins		Date of capture	No. of Winter-rings [2]
				Pre-caudal	Caudal	Total				right	left		
1	35.2	♀	V	24	33	57	14	?	4 + 15	9	?	1924. Febr. 25	?
2	27.3	♀	V	26	32	58	13	?	3 + 16	9	9	—	4 r
3	35.5	♀	V	25	33	58	13	16	?	9	9	—	7 r
4	30.6	♂	V-VI	24	33	57	14	15	4 + 15	9	10	—	6 r
5	32.7	♂	V-VI	25	33	58	14	15	3 + 14	9	9	—	6 r
6	31.1	♂	V-VI	23	34	57	13	15	4 + 14	9	9	—	5 r
7	34.0	♂	V-VI	23	34	57	14	14	?	9	9	—	ca. 7 r
8	37.8	♂	V-VI	26	32	58	14	15	3 + 15	9	9	—	12 r
9	33.7	♂	V-VI	24	33	57	14	15	3 + 14	9	9	—	6 r
10	35.2	♂	V-VI	25	33	58	15	14	3 + 14	9	9	—	ca. 9 r
11	35.0	♂	V-VI	24	33	57	14	14	4 + 14	9	9	—	8 r
12	36.8	♂	V-VI	25	33	58	13	15	4 + 14	9	9	—	9 r
13	28.2	♂	V-VI	26	32	58	14	14	3 + 15	9	9	—	ca. 4 r
14	33.3	♂	V-VI	26	31	57	14	16	3 + 14	9	9	—	7 r
15	38.0	♂	V-VI	23	32	55	14	?	3 + 15	9	9	—	9 r
16	29.0	♂	V-VI	24	34	58	14	15	3 + 16	9	9	—	4—5 r
17	ca.37.0	♂	V-VI	25	33	58	14	15	?	9	9	—	?
18	36.6	♀	V-VI	24	33	57	14	15	3 + 15	9	9	—	7 r
19	36.2	♀	V-VI	24	33	57	12	16	3 + 15	9	9	—	11 r
20	34.5	♀	V-VI	24	35	59	13	16	3 + 16	9	9	—	7 r
21	33.2	♀	V-VI	25	32	57	13	15	4 + 14	9	9	—	6 r
22	37.3	♀	V-VI	24	34	58	12	?	3 + 15	9	9	—	11 r
23	28.3	♀	V-VI	24	33	57	14	15	defect	9	9	—	5—6 r
24	35.0	♀	V-VI	25	33	58	15	?	4 + 14	9	8	—	ca. 7 r
25	37.7	♀	V-VI	24	33	57	15	16	3 + 15	9	9	—	ca. 7 r
26	33.5	♀	V-VI	24	32	56	?	?	3 + 15	9	9	—	5 r
27	31 8	♀	V-VI	24	34	58	14	?	3 + 14	9	9	—	4 r
28	35.7	♀	V-VI	25	32	57	14	?	3 + 14	9	9	—	6 r
29	36.5	♀	V-VI	24	33	57	13	15	3 + 16	9	9	—	8 r
30	34.8	♀	V-VI	25	33	58	?	15	3 + 14	9	9	—	6 r
31	33.5	♀	V-VI	24	34	58	15	?	3 + 14	?	9	1924 March 15	ca. 7 r
32	28.7	♂	VII	25	33	58	13	?	3 + 16	9	9	—	?
33	35.7	♀	VI	24	33	57	13	15	4 + 14	9	9	1924. April 20.	10 r
34	36.4	♀	VI	25	33	58	14	14	3 + 15	9	9	—	11 r
35	37.0	♀	VI				15	15	4 + 14	9	9	—	10 r
36	37.5	♀	VI	24	33	57	15	15	4 + 13	9	9	—	10 r
37	36.4	♀	VI	24	33	57	13	15	3 + 15	9	9	—	ca. 8 r
38	31.3	♀	VI	25	32	57	13	15	3 + 16	9	9	—	4 r
39	37.2	♀	VI	24	33	57	14	15	3 + 15	9	9	—	9 r
40	36.3	♀	VI	25	34	59	15	15	4 + 15	9	9	—	ca. 9 r
41	35.5	♀	VI	24	33	57	14	15	3 + 15	9	9	—	11 r

[1]) unbranched plus branched.

[2]) The letter r after the figure denoting number of Winter-rings indicates that the last Winter-ring is situated quite at the margin, not inside the margin.

No.	Length cm.	Sex	Maturity	Vertebrae			Keeled scales K_2	Branched Rays in Dorsal fin	Rays in anal fin [1])	Rays in ventral fins		Date of capture	No. of winter-rings
				Pre caudal	Caudal	Total				right	left		
42	29.8	♀	VI	26	32	58	14	15	4 + 15	9	9	1924. April 20.	?
43	36.2	♂	VI	23	34	57	14	15	3 + 14	9	9	—	8 r
44	35.7	♂	VI	25	33	58	15	15	3 + 14	9	9	—	8 r
45	35.2	♂	VI	25	33	58	13	15	4 + 14	9	9	—	ca. 10 r
46	37.3	♂	VI-VII	25	33	58	14	16	3 + 16	9	9	— 3.	9 r
47	34.2	♀	V-VI	24	33	57	14	16	3 + 14	9	9	— 30.	ca. 8 (r)
48	33.2	♀	VII	25	32	57	14	15	3 + 15	9	9	—	6 r
49	33.2	♂	VI-VII	24	34	58	14	16	3 + 15	9	9	—	6 r
50	38.0	♂	VI-VII	24	34	58	14	15	3 + 15	9	9	—	ca. 11 r
51	33.7	♂	VII	24	33	57	14	15	3 + 15	8	9	—	6 r
52	31.6	♂	VI	25	32	57	13	15	3 + 15	9	8	1925. Febr. 15.	
53	30.8	♂	VI	25	34	59	14	16	3 + 15	9	9	—	
54	29.5	♂	VI	23	33	56	13	?	?	9	9	—	
55	28.8	♂	VI	25	32	57	13	14	3 + 14	9	9	—	
56	26.7	♂	VI	25	31	56	12	14	4 + 13	9	9	—	
57	28.3	♂	VI	24	33	57	13	?	17	?	?	—	
58	30.1	♂	VI	24	34	58	13	?	18	?	9	—	
59	28.3	♂	VI	23	34	57	13	?	?	9	9	—	
60	31.1	♂	VI	25	32	57	?	15	?	9	9	—	
61	30.7	♂	VI	23	34	57	14	15	4 + 14	9	9	—	
62	30.6	♀	VI	26	32	58	14	?	18	9	9	—	
63	30.2	♀	VI	24	34	58	14	15	3 + 14	9	8	—	
64	29.0	♀	VI	24	34	58	13	?	?	9	9	—	
65	29.9	♀	VI	24	34	58	15	14	?	9	10	—	
66	30.8	♀	VI	24	32	56	13	15	3 + 14	8	9	—	
67	33.5	♀	VI	23	33	56	13	?	4 + 15	9	9	—	
68	33.4	♀	VI	24	34	58	14	16	3 + 14	9	9	—	
69	27.5	♀	VI	26	31	57	12	15	4 + 16	9	9	—	
70	31.7	♂	VI	25	33	58	13	15	3 + 15	9	9	—	
71	31.8	♂	VI	23	34	57	14	?	?	?	?	—	
72	30.2	♂	VI	24	34	58	14	16	17	9	9	—	
73	28.3	♂	VI	25	33	58	13	15	4 + 15	9	9		
74	28.2	♂	VI	25	33	58	14	?	?	?	?	—	
75	27.7	♂	VI	24	34	58	14	16	?	9	9	—	
76	27.8	♂	VI	24	35	59	14	15	3 + 14	9	9		
77	31.3	♂	VI	24	34	58	13	14	18	9	9	—	
78	28.3	♂	VI	25	33	58	14	?	18	9	9	—	
79	27.8	♂	VI	25	32	57	15	16	3 + 13	9	9	—	
80	30.3	♀	VI	25	33	58	14	15	3 + 14	9	9		
81	30 5	♀	VI	25	33	58	14	16	18	9	9	—	
82	29.3	♀	VI	24	33	57	?	?	?	?	?	—	
83	31.8	♀	VI	26	32	58	14	16	3 + 15	9	9	—	
84	29.7	♀	VI	25	33	58	12	?	3 + 15	9	9		
85	28.5	♀	VI	24	34	58	14	?	?	?	?	—	

[1]) unbranched plus branched.

B. Herrings from Fuglasker.

Caught in Drift Nets. Sept. 14. 1924.

No.	Length cm	Sex	Maturity	Vertebrae			Keeled scales K_2	Rays in Anal fin	Rays in ventral fins		No. of winter-rings
				Pre-Caudal	Caudal	Total			right	left	
1	28.0	♂	III	25	33	58	13	3 + 14	9	9	ca. 6
2	28.8	♂	III	24	34	58	13	4 + 15	9	9	ca. 5
3	30.8	♂	IV	24	34	58	14	4 + 14	9	9	4
4	30.6	♂	IV	25	33	58	14	3 + 15	9	9	ca. 4
5	32.2	♂	IV	24	33	57	14	3 + 13	9	8	6
6	31.0	♂	IV	25	33	58	15	3 + 15	9	9	4
7	31.3	♂	IV	24	33	57	15	2 + 15	9	8	5
8	30.0	♀	III	?	?	?	13	3 + 16	9	0	4
9	32.2	♀	III	25	33	58	13	3 + 14	9	9	4
10	30.0	♀	III	24	33	57	13	3 + 15	9	9	4
11	30.5	♀	III	24	33	57	13	3 + 15	9	9	ca. 6
12	30.5	♀	IV	24	33	57	14	4 + 15	9	9	4
13	30.2	♂	VII	23	34	57	12	4 + 16	8	8	4

C. Herrings from off Køgur Huk N. W. Iceland.

Caught in Drift Nets. Sept. 6. 1924.

No.	Length cm	Sex	Maturity	Vertebrae			Keeled scales K_2	Rays in Anal fin	Rays in ventral fins		No of winter-rings
				Pre-Caudal	Caudal	Total			right	left	
1	35.3	♀	VII-VIII	27	30	57	14	3 + 14	9	9	7
2	34.6	♀	VII-VIII	26	31	57	14	3 + 15	10	10	7
3	36.2	♀	VII-VIII	25	33	58	13	3 + 16	9	9	8
4	37.0	♀	VII-VIII	25	32	57	13	3 + 16	9	9	8
5	37.4	♀	VII-VIII	26	32	58	12	4 + 15	8	8	9
6	36.5	♀	VII-VIII	26	32	58	13	4 + 14	9	9	9
7	36.0	♀	VII-VIII	24	33	57	14	3 + 15	9	9	8
8	36.0	♀	VII-VIII	24	32	56	13	4 + 14	9	9	9
9	35.8	♀	VII-VIII	24	33	57	14	3 + 15	8	9	7
10	35.7	♀	VII-VIII	25	31	56	14	3 + 14	9	9	ca. 7
11	35.3	♀	VII-VIII	25	33	58	13	4 + 14	9	9	8
12	37.2	♂	VII-VIII	27	31	58	13	3 + 15	10	10	11
13	37.0	♂	VII-VIII	24	33	57	14	3 + 14	9	9	8
14	36.3	♂	VII-VIII	24	33	57	14	3 + 14	8	8	7
15	34.0	♂	VII-VIII	24	33	57	14	3 + 15	9	9	7
16	34.3	♂	VII-VIII	?	?	?	12	3 + 14	9	9	ca. 11
17	35.5	♂	VII-VIII	25	32	57	14	4 + 15	9	9	9

No.	Length cm	Sex	Maturity	Vertebrae			Keeled scales K_3	Rays in Anal fin	Rays in ventral fins		No. of winter-rings
				Pre-Caudal	Caudal	Total			right	left	
18	35.8	♂	VII-VIII	24	33	57	13	3+16	9	9	ca. 7
19	36.5	♂	VII-VIII	24	33	57	14	?	9	9	7
20	37.0	♂	VII-VIII	28	30	58	15	3+16	9	9	9
21	35.0	♂	VII-VIII	25	32	57	14	3+14	9	9	6
22	36.8	♂	VII-VIII	23	34	57	14	3+15	9	9	9
23	35.5	♂	VII-VIII	26	31	57	13	3+15	8	8	12
24	34.5	♂	VII-VIII	24	33	57	14	4+14	9	9	6
25	36.2	♂	VII-VIII	25	32	57	14	3+15	9	9	10
26	35.0	♂	VII-VIII	24	33	57	14	3+16	9	9	9
27	34.7	♂	VII-VIII	25	31	56	14	3+15	9	9	8
28	36.5	♂	VII-VIII	26	31	57	14	3+14	9	9	ca. 10
29	35.3	♂	VII-VIII	26	30	56	13	?	9	8	9
30	37.3	♂	VII-VIII	26	31	57	13	3+14	9	9	9
31	35.8	♂	VII-VIII	26	31	57	13	3+16	9	9	ca. 7
32	33.5	♂	VII-VIII	24	32	56	14	4+15	9	9	5
33	34.2	♀	VII-VIII	24	33	57	15	3+15	8	8	8
34	36.0	♀	VII-VIII	26	32	58	14	3+15	9	9	ca. 7
35	37.6	♀	VII-VIII	24	34	58	13	4+14	9	9	10
36	35.6	♀	VII-VIII	25	32	57	13	3+16	9	9	7
37	35.3	♀	VII-VIII	26	31	57	13	3+15	9	9	ca. 9
38	36.3	♂	III-IV	25	33	58	14	3+15	9	9	7
39	37.2	♂	III-IV	25	33	58	13	3+15	9	9	10
40	35.5	♂	III-IV	25	33	58	13	4+13	10	9	7
41	35.5	♂	III-IV	25	32	57	14	3+15	9	9	5
42	36.7	♂	III-IV	25	31	56	14	4+14	9	9	8
43	33.6	♂	III-IV	25	33	58	14	3+14	9	9	6
44	35.2	♂	III-IV	26	32	58	14	3+15	9	9	ca. 8
45	35.7	♂	III-IV	25	31	56	13	3+16	9	9	8
46	34.7	♂	III-IV	25	32	57	14	3+15	9	9	7
47	33.8	♂	III-IV	24	33	57	14	3+15	9	9	7
48	35.6	♂	III-IV	24	33	57	14	3+12	9	9	7
49	37.5	♂	III-IV	25	33	58	15	3+14	9	9	10

D. Herrings from E. of Malmey.

Caught in Purse Seine. July 22. 1924. Maturity III-IV.

No.	Length cm	Vertebrae			Keeled scales K_2	Rays in Anal fin	No.	Length cm	Vertebrae			Keeled scales K_2	Rays in Anal fin
		Pre-Caudal	Caudal	Total					Pre-Caudal	Caudal	Total		
1	33.7	25	33	58	14	3 + 15	41	36.6	25	32	57	13	3 + 15
2	34.2	24	33	57	14	3 + 15	42	34.2	23	35	58	14	4 + 15
3	34.0	26	32	58	14	3 + 15	43	32.9	24	33	57	15	3 + 15
4	34.9	27	31	58	13	3 + 15	44	34.4	24	35	59	14	4 + 15
5	35.5	24	33	57	14	4 + 14	45	35.7	25	33	58	14	3 + 15
6	30.3	23	34	57	?	3 + 14	46	34.4	25	33	58	15	3 + 15
7	33.1	24	34	58	14	3 + 17	47	35.5	23	35	58	14	4 + 15
8	34.2	24	33	57	14	4 + 14	48	32.2	25	32	57	14	3 + 16
9	33.2	?	?	?	14	3 + 15	49	32.7	25	32	57	14	3 + 14
10	34.1	26	32	58	14	?	50	34.4	25	33	58	14	3 + 16
11	33.8	24	33	57	14	3 + 15	51	32.2	24	34	58	15	3 + 14
12	31.8	24	33	57	14	3 + 15	52	35.1	25	33	58	14	3 + 15
13	35.1	26	33	59	14	4 + 15	53	32.8	25	33	58	14	4 + 14
14	33.1	24	33	57	14	4 + 15	54	35.3	24	34	58	13	3 + 17
15	33.6	24	34	58	14	3 + 15	55	33.0	25	33	58	14	4 + 15
16	34.9	23	34	57	13	4 + 15	56	34.1	25	32	57	13	4 + 16
17	35.5	24	34	58	13	3 + 16	57	34.6	25	33	58	?	3 + 15
18	33.6	23	33	56	13	3 + 16	58	34.8	23	33	56	13	3 + 16
19	34.6	26	33	59	14	3 + 16	59	34.6	26	31	57	13	3 + 16
20	32.0	25	31	56	?	?	60	31.1	25	33	58	14	3 + 15
21	32.3	23	34	57	13	4 + 14	61	33.3	25	32	57	15	3 + 15
22	34.6	25	32	57	14	3 + 17	62	31.6	24	33	57	15	4 + 15
23	31.8	24	33	57	13	4 + 15	63	34.3	24	34	58	14	3 + 16
24	32.6	25	33	58	14	3 + 15	64	33.4	23	33	56	14	3 + 14
25	33.0	23	34	57	?	3 + 16	65	33.5	23	33	56	14	3 + 13
26	34.7	26	32	58	14	3 + 16	66	34.3	25	33	58	13	4 + 14
27	34.2	24	35	59	13	3 + 17	67	31.2	24	33	57	14	3 + 17
28	32.6	24	32	56	14	4 + 15	68	34.3	24	33	57	14	3 + 16
29	35.2	25	32	57	14	3 + 15	69	33.1	25	32	57	13	3 + 15
30	31.6	24	34	58	?	4 + 16	70	32.0	25	32	57	14	4 + 14
31	33.9	25	34	59	14	3 + 15	71	34.6	25	32	57	13	4 + 15
32	34.4	24	34	58	14	3 + 15	72	33.5	25	32	57	14	4 + 16
33	33.5	23	33	56	?	3 + 16	73	34.9	25	34	59	14	3 + 15
34	33.4	22	35	57	14	4 + 15	74	33.8	25	33	58	14	3 + 16
35	34.1	25	33	58	14	3 + 17	75	33.3	26	32	58	13	?
36	33.0	23	34	57	14	3 + 15	76	36.6	25	33	58	15	?
37	33.7	26	32	58	12	4 + 15	77	37.1	24	32	56	13	3 + 16
38	34.3	24	33	57	14	4 + 15	78	35.5	24	33	57	15	?
39	33.9	24	33	57	15	4 + 15	79	34.9	24	33	57	13	3 + 16
40	34.5	25	32	57	13	3 + 15	80	34.8	24	35	59	14	3 + 15

No.	Length cm	Vertebrae			Keeled scales K_2	Rays in Anal fin	Rays in ventral fins	
		Pre-Caudal	Caudal	Total			r.	l.
81	35.1	24	33	57	14	3 + 15		
82	34.0	24	33	57	14	4 + 14		
83	33.5	25	32	57	14	?		
84	31.4	25	33	58	?	3 + 16		
85	34.5	25	31	56	14	4 + 13		
86	34.2	25	33	58	13	3 + 15		
87	34.6	27	32	59	14	3 + 16	9	9
88	34.5	24	32	56	14	4 + 14	9	9
89	33.6	24	33	57	14	3 + 16	9	9
90	33.9	24	33	57	14	3 + 15	9	9
91	33.5	24	33	57	14	4 + 15	9	9
92	31.6	24	33	57	14	3 + 14	9	9
93	33.5	24	32	56	13	3 + 16	9	9
94	32.9	25	32	57	16	3 + 15	9	9
95	37.1	26	32	58	14	3 + 15	9	9
96	35.0	25	34	59	15	4 + 14	9	9
97	34.3	24	34	58	13	4 + 16	9	9
98	34.3	24	34	58	15	3 + 16	9	9
99	34.1	24	34	58	14	3 + 16	9	9
100	37.2	24	34	58	14	3 + 15	9	9
101	33.9	25	32	57	12	4 + 16	9	9
102	34.9	24	33	57	14	3 + 13	9	9
103	34.3	25	32	57	15	3 + 15	9	9
104	32.7	24	33	57	15	4 + 14	9	9
105	34.5	25	32	57	14	3 + 15	9	9
106	33.5	24	33	57	14	3 + 15	9	9
107	35.3	24	34	58	14	3 + 15	9	9
108	35.3	25	33	58	14	4 + 15	9	9
109	34.5	24	32	56	13	4 + 15	9	9
110	34.0	25	32	57	14	3 + 16	9	9
111	35.0	26	32	58	13	3 + 17	9	9
112	34.5	24	34	58	13	4 + 16	9	9
113	36.8	25	32	57	14	3 + 15	9	9
114	34.1	24	33	57	15	3 + 14	9	8
115	34.4	25	32	57	14	3 + 15	9	9
116	32.0	24	33	57	14	3 + 15	9	9
117	35.7	24	34	58	15	3 + 14	?	9
118	35.3	24	33	57	13	3 + 16	9	9
119	33.4	25	32	57	14	3 + 15	9	9
120	34.7	24	34	58	14	3 + 15	9	9
121	34.5	25	34	59	15	3 + 15	9	9
122	34.2	25	32	57	14	3 + 15	9	9
123	35.7	25	33	58	13	3 + 16	9	9
124	32.3	25	33	58	13	?	9	9
125	34.0	26	31	57	16	3 + 14	9	9
126	36.7	25	32	57	14	3 + 14	9	9
127	34.6	24	34	58	14	3 + 16	9	9
128	32.7	27	31	58	13	4 + 13	9	9
129	34.6	25	33	58	13	3 + 15	9	9
130	34.0	24	32	56	15	4 + 14	9	9
131	36.1	24	34	58	15	4 + 14	9	9
132	35.3	23	34	57	14	4 + 15	9	9
133	31.8	25	34	59	14	3 + 16	9	9
134	34.7	26	32	58	14	3 + 15	9	9
135	35.1	24	34	58	14	4 + 16	9	9
136	33.6	25	33	58	14	4 + 16	9	9
137	36.7	24	33	57	14	4 + 13	9	9
138	34.5	26	33	59	14	4 + 16	8	8
139	34.7	25	33	58	14	3 + 15	9	9
140	37.0	25	33	58	13	3 + 15	9	9
141	38.2	26	33	59	?	3 + 17	9	9
142	34.7	23	34	57	14	3 + 16	9	9
143	36.8	25	33	58	14	3 + 15	9	9
144	32.6	25	33	58	14	4 + 14	9	9

E. Herrings from the North of Iceland off Eyjafjord. 66° 11' N, 18° 25' W.
Caught in Drift Nets. Sept. 12. 1924.

No.	Length cm	Sex	Maturity	Fat	Vertebrae			Keeled scales K_2	Branched Rays in Dorsal fin	Rays in Anal fin	Rays in Ventral fins		No. of winter-rings
					Pre-Caudal	Caudal	Total				right	left	
1	37.2	♀	VIII	0	23	34	57	13	15	4 + 16	9	9	10
2	37.5	♀	VIII	1	25	32	57	13	17	4 + 16	9	9	10
3	36.2	♀	VIII	2	25	32	57	14	16	3 + 16	9	9	8
4	37.0	♀	VIII	1	25	33	58	13	15	4 + 15	9	9	8
5	35.5	♀	VIII	1	24	34	58	14	16	3 + 16	9	9	7
6	36.8	♀	VIII	1	25	31	56	13	15	4 + 14	9	9	7
7	38.0	♀	VIII	0	23	34	57	14	16	4 + 14	9	9	12
8	36.0	♀	VIII	1	24	33	57	14	16	3 + 16	9	9	6
9	34.6	♀	VIII	1	24	32	56	14	15	3 + 14	9	9	7
10	36.5	♀	VIII	1	25	32	57	14	15	3 + 15	9	9	ca. 8
11	36.0	♀	VIII	1	25	33	58	14	16	4 + 16	9	9	ca. 7
12	36.0	♀	VIII	1	24	33	57	14	15	3 + 14	9	9	10
13	37.0	♀	VIII	1	25	33	58	14	15	3 + 16	9	9	10
14	37.6	♂	VIII	1	24	33	57	14	16	3 + 15	9	9	ca. 8
15	36.5	♂	VIII	1	26	32	58	13	16	3 + 15	8	8	ca. 6
16	35.0	♂	VIII	1	26	31	57	13	15	4 + 15	9	9	7
17	35.1	♂	VIII	1	24	33	57	14	15	3 + 14	9	9	10
18	36.0	♂	VIII	1	25	31	56	13	15	3 + 15	9	9	9
19	34.7	♂	VIII	0	24	33	57	14	14	3 + 15	9	8	6
20	34.5	♂	VIII	1	24	33	57	14	15	3 + 17	10	9	ca. 7
21	36.5	♂	VIII	1	28	29	57	14	16	4 + 15	8	8	8
22	35.0	♂	VIII	1	24	32	56	13	15	3 + 15	9	9	5
23	37.8	♂	VIII	1	25	32	57	13	15	4 + 14	9	9	6
24	35.2	♂	VIII	1	26	31	57	13	16	3 + 15	9	9	9
25	35.1	♂	VIII	0	25	32	57	13	15	3 + 13	9	9	8
26	36.6	♂	VIII	0	24	32	56	15	15	3 + 16	9	9	7
27	37.2	♂	VIII	1	25	31	56	15	15	3 + 16	9	9	7
28	35.5	♂	VIII	1	24	33	57	14	15	3 + 15	9	9	8
29	35.7	♂	VIII	1	25	32	57	15	16	3 + 16	9	9	8
30	35.1	♂	VIII	1	25	33	58	14	17	3 + 16	9	9	7
31	37.0	♂	VIII	1	24	33	57	14	15	3 + 15	9	9	8
32	35.2	♀	VIII	3	25	33	58	13	16	3 + 16	9	9	ca. 9
33	36.7	♀	VIII	0	24	33	57	12	16	3 + 15	9	10	9
34	34.0	♀	VIII	0	22	34	56	13	15	3 + 15	8	8	6
35	34.6	♀	VIII	1	23	34	57	14	15	3 + 14	9	9	6
36	36.8	♀	VIII	1	24	33	57	14	16	3 + 16	9	9	8
37	36.7	♀	VIII	1	25	32	57	13	15	3 + 15	9	9	9
38	36.2	♀	VIII	1	24	33	57	15	15	3 + 15	9	9	6
39	36.5	♀	VIII	2	23	33	56	13	16	3 + 15	9	10	ca. 10
40	35.5	♀	VIII	1	24	33	57	14	16	3 + 15	9	9	7

No.	Length cm	Sex	Maturity	Fat	Vertebrae			Keeled scales K₁	Branched Rays in Dorsal fin	Rays in Anal fin	Rays in ventral fins		No. of winter-rings
					Pre-Caudal	Caudal	Total				right	left	
41	36.0	♀	VIII	2	25	31	56	13	15	3 + 15	9	9	10
42	35.5	♂	VIII	2	24	34	58	14	16	4 + 15	9	9	8
43	37.5	♂	VIII	1	25	32	57	13	15	3 + 15	9	9	8
44	36.2	♂	VIII	1	24	33	57	13	15	3 + 16	9	8	ca. 8
45	38.5	♂	VIII	1	24	33	57	14	16	3 + 16	9	9	ca. 9
46	36.2	♂	VIII	1	25	32	57	14	15	3 + 15	9	9	ca. 10
47	34.4	♂	VIII	0	24	33	57	15	16	4 + 15	9	9	8
48	36.2	♀	III VIII[1]	3	26	31	57	12	15	3 + 15	9	9	8
49	35.3	♀	III VIII	2	24	32	56	13	15	3 + 14	9	9	7
50	35.0	♀	III VIII	2	27	31	58	14	15	3 + 15	9	9	8
51	34.8	♀	III VIII	1	25	33	58	14	16	3 + 15	9	9	ca. 8
52	34.6	♀	III VIII	2	25	33	58	14	14	4 + ?	9	9	11
53	36.1	♀	III VIII	1	25	32	57	14	14	4 + 13	9	9	ca. 10
54	35.0	♀	III VIII	1	24	33	57	15	15	4 + 15	9	9	10
55	37.5	♀	III VIII	1	25	32	57	14	15	4 + 14	9	9	8
56	36.4	♀	III VIII	1	25	32	57	14	15	4 + 15	9	9	9
57	37.0	♀	III VIII	1	24	33	57	14	16	3 + 16	9	9	8
58	37.5	♀	III VIII	1	24	34	58	14	16	3 + 15	8	9	8
59	34.5	♀	III VIII	2	24	33	57	13	15	3 + 16	9	9	7
60	34.5	♀	III VIII	1	25	32	57	14	15	3 + 16	9	9	7
61	35.8	♀	III VIII	2	25	31	56	13	15	4 + 14	9	9	9
62	34.5	♀	III VIII	1	24	32	56	14	16	4 + 15	9	9	8
63	34.2	♂	III VIII	2	25	32	57	13	15	3 + 15	9	9	6
64	37.0	♂	III VIII	3	24	33	57	13	16	3 + 16	9	9	8
65	37.4	♂	III VIII	3	25	32	57	13	15	3 + 15	9	9	ca. 6
66	37.2	♂	III VIII	3	25	32	57	13	15	3 + 16	10	10	10
67	36.3	♂	III VIII	3	25	33	58	14	15	3 + 15	9	9	9
68	36.0	♂	III VIII	2	24	33	57	14	15	3 + 17	9	8	6
69	36.8	♂	III VIII	3	24	34	58	14	16	2 + 15	9	9	9
70	33.5	♂	III VIII	2	25	32	57	13	15	3 + 15	9	9	8
71	36.5	♂	III VIII	3	25	32	57	15	16	3 + 15	9	9	10
72	36.5	♂	III VIII	3	24	34	58	14	15	3 + 15	9	9	11
73	36.0	♀	III VIII	2	25	33	58	?	15	3 + 15	9	9	8
74	36.5	♀	III VIII	3	25	32	57	14	16	3 + 16	9	9	7
75	36.5	♀	III VIII	2	25	33	58	14	15	4 + 17	9	9	10
76	36.0	♀	III VIII	1	25	33	58	14	15	3 + 15	9	9	7
77	34.2	♀	III VIII	3	23	34	57	14	15	3 + 15	9	9	ca. 13
78	36.5	♀	III VIII	2	25	33	58	14	15	3 + 15	9	9	8
79	36.5	♀	III VIII	3	24	33	57	14	16	3 + 17	9	9	7
80	36.7	♀	III VIII	2	24	33	57	13	15	3 + 16	9	9	8
81	34.8	♀	III VIII	3	25	32	57	14	14	3 + 15	9	9	9
82	36.5	♀	III VIII	3	26	31	57	15	15	3 + 14	9	9	8
83	35.2	♀	III VIII	2	24	33	57	14	15	4 + 14	9	9	13
84	34.2	♀	III VIII	2	24	33	57	14	15	3 + 15	9	9	8

[1] indicates III or VIII.

No.	Length cm	Sex	Maturity	Fat	Vertebrae			Keeled Scales K_2	Branched Rays in Dorsal fin	Rays in Anal fin	Rays in ventral fins		No. of winter-rings
					Pre-Caudal	Caudal	Total				right	left	
85	33.0	♀	III VIII[1]	2	24	34	58	14	15	3 + 16	9	9	6
86	36.7	♀	III VIII	2	25	32	57	14	14	3 + 15	9	9	8
87	33.3	♀	III VIII	1	24	34	58	13	15	3 + 15	9	9	6
88	37.0	♀	III VIII	3	25	32	57	14	16	3 + 15	9	9	9
89	37.0	♀	III VIII	2	23	35	58	13	16	3 + 16	9	9	10
90	35.3	♀	III VIII	3	23	33	56	13	15	3 + 14	9	9	9
91	35.0	♀	III VIII	3	25	32	57	13	14	4 + 14	9	9	10
92	37.5	♀	III VIII	2	24	33	57	14	15	4 + 13	9	8	ca. 10
93	37.2	♀	III VIII	3	26	32	58	15	15	3 + 16	9	9	9
94	36.0	♀	III VIII	3	25	32	57	14	15	4 + 14	8	9	10
95	36.5	♀	III VIII	2	23	34	57	14	15	4 + 15	9	9	10
96	37.5	♀	III VIII	2	25	32	57	12	17	4 + 16	9	8	8
97	35.2	♀	III VIII	2	25	32	57	14	14	3 + 14	9	9	7
98	36.0	♀	III VIII	3	25	33	58	14	16	3 + 15	9	9	8
99	38.3	♀	III VIII	3	24	32	56	14	16	4 + 15	9	9	11
100	37.2	♀	III VIII	3	24	33	57	13	15	3 + 16	9	9	9
101	34.8	♀	III VIII	2	24	32	56	13	15	3 + 14	8	8	ca. 7
102	35.6	♀	III VIII	1	25	33	58	15	15	3 + 15	9	9	7
103	34.5	♀	III VIII	2	25	32	57	13	?	3 + 16	9	9	6
104	35.3	♀	III VIII	3	23	34	57	13	15	3 + 17	9	9	7
105	34.2	♀	III VIII	3	25	32	57	13	14	3 + 14	9	9	7
106	36.2	♂	III VIII	3	24	33	57	14	15	3 + 15	9	9	10
107	35.6	♂	III VIII	1	24	34	58	14	16	3 + 15	9	9	ca. 7
108	36.3	♂	III VIII	3	25	33	58	13	16	3 + 14	9	9	ca. 8
109	35,5	♂	III VIII	3	24	33	57	14	15	3 + 16	9	9	ca. 7
110	35.5	♂	III VIII	2	26	32	58	14	15	4 + 14	9	9	8
111	37.3	♂	III VIII	2	25	32	57	14	15	3 + 15	9	9	8
112	36.2	♂	III VIII	2	24	34	58	14	16	3 + 16	9	9	13
113	36.3	♂	III VIII	1	24	33	57	14	16	3 + 16	9	9	8
114	35.0	♂	III VIII	3	25	31	56	14	15	3 + 15	9	9	6
115	37.5	♂	III VIII	2	24	33	57	14	16	3 + 16	8	8	7
116	36.2	♂	III VIII	1	25	32	57	14	16	4 + 14	9	9	8
117	37.0	♀	IV	1	24	33	57	14	15	3 + 16	9	9	10
118	37.7	♀	IV	1	25	32	57	15	?	3 + 16	9	9	10
119	36.4	♀	IV	2	25	32	57	?	15	4 + 15	9	9	8
120	35.2	♀	IV	2	25	32	57	15	14	4 + 14	9	9	7
121	35.3	♀	IV	2	25	33	58	14	15	4 + 15	9	9	6
122	37.0	♂	IV	2	24	33	57	14	15	3 + 15	9	9	10
123	37.2	♂	IV	2	25	34	59	15	15	4 + 14	9	9	ca. 7
124	35.2	♂	IV	1	25	33	58	13	15	3 + 16	9	9	7
125	34.5	♀	IV	3	23	35	58	14	15	3 + 15	9	9	6
126	35.6	♀	IV	1	25	33	58	14	abn.	3 + 14	9	9	7
127	37.0	♀	IV	1	23	34	57	14	15	3 + 15	9	9	7
128	31.8	♂	IV	2	24	34	58	15	14	4 + 16	9	9	6

[1] indicates III or VIII.

No.	Length cm	Sex	Maturity	Fat	Vertebrae			Keeled Scales K_2	Branched Rays in Dorsal	Rays in Anal fin	Rays in ventral fins		No. of winter-rings
					Pre-Caudal	Caudal	Total				right	left	
129	36.0	♂	IV	1	25	32	57	13	15	?	9	9	7
130	35.0	♂	IV	2	25	32	57	11	15	4 + 16	9	8	9
131	35.8	♂	IV-V	2	24	33	57	15	16	3 + 16	9	9	10
132	34.6	♂	IV-V	2	25	32	57	13	16	3 + 15	9	9	9
133	35.0	♂	IV-V	2	26	32	58	13	15	4 + 16	9	9	ca. 10
134	34.6	♂	IV-V	2	24	33	57	14	15	3 + 14	9	9	10
135	35.8	♂	IV-V	2	24	34	58	13	14	4 + 14	9	9	ca. 8
136	36.0	♂	IV-V	2	23	34	57	13	16	3 + 16	9	9	5
137	34.7	♂	IV-V	1	24	34	58	13	16	4 + 16	9	9	10
138	34.8	♂	IV-V	1	25	33	58	14	14	3 + 15	9	9	11
139	37.1	♂	IV-V	2	24	33	57	14	15	3 + 15	9	9	9
140	35.7	♂	IV-V	1	25	33	58	13	16	4 + 16	9	9	7
141	35.0	♂	IV-V	2	24	34	58	13	14	3 + 15	9	9	11
142	36.4	♂	IV-V	2	25	33	58	15	15	3 + 15	9	9	7
143	36.5	♂	IV-V	2	24	34	58	14	15	3 + 15	9	9	11
144	34.8	♂	VI-V	2	24	34	58	14	15	3 + 15	9	9	8
145	36.5	♂	VI-V	2	24	34	58	14	16	3 + 15	9	9	6
146	37.0	♂	VI-V	2	24	34	58	13	16	4 + 15	9	9	8
147	35.6	♂	VI-V	2	25	32	57	14	15	3 + 14	9	9	9
148	36.8	♂	VI-V	2	24	32	56	14	15	3 + 14	9	9	8
149	37.2	♂	VI-V	2	24	33	57	13	15	4 + 15	9	9	10
150	37.0	♂	VI-V	2	25	32	57	14	16	3 + 15	9	9	8
151	36.8	♂	IV-V	2	24	33	57	14	16	3 + 16	9	9	9
152	36.7	♂	IV-V	3	24	34	58	15	16	3 + 15	9	10	8
153	36.5	♂	IV-V	3	25	32	57	14	16	3 + 15	9	9	9
154	35.8	♂	IV-V	2	24	33	57	13	16	3 + 15	9	9	7
155	36.2	♂	IV-V	2	23	34	57	13	16	3 + 15	9	9	6
156	36.0	♂	IV-V	2	24	33	57	14	16	3 + 16	9	9	10
157	34.5	♂	IV-V	2	25	33	58	12	15	3 + 15	9	9	7
158	36.2	♂	IV-V	2	23	34	57	15	15	3 + 15	9	9	7
159	35.2	♂	IV-V	2	25	33	58	15	15	3 + 14	9	9	8
160	34.2	♂	IV-V	2	25	33	58	14	16	4 + 16	9	9	9
161	36.5	♂	IV-V	2	24	33	57	13	15	3 + 16	9	9	ca. 10
162	34.0	♂	IV-V	1	24	33	57	14	14	3 + 15	9	9	ca. 10
163	36.5	♂	IV-V	2	26	32	58	13	15	3 + 16	9	9	8
164	36.6	♂	IV-V	1	25	33	58	15	15	3 + 15	9	9	8
165	33.5	♂	IV-V	2	24	34	58	14	15	3 + 15	9	9	?
166	35.7	♀	II	3	25	32	57	12	15	4 + 14	9	9	9

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The Frequency of young Cod etc. on the North and East Coasts of Iceland during a period of years. With a Survey of the Life-History of the Iceland Cod.

By

Johs. Schmidt.

The Cod *(Gadus callarias*, L.*)* is unquestionably the most important fish for the »North-Western Area Committee«. As a matter of fact, the Icelandic waters form one of the great cod-fishing centres of the world, where fishermen from many lands assemble to take their toll of the enormous quantities of cod growing up on these grounds.

All previous observations show that both Iceland and the Faroes are self-contained areas, both for cod and also for most of the other food-fishes.

The life-history of the cod is known insofar as regards its broad general outlines. We know, for the most part, its spawning grounds and spawning season; and we have followed its development from the egg *via* larval and postlarval stages up to the point where pelagic life comes to an end, and the little fish becomes a bottom form. It is necessary, of course, to be able to distinguish cod at these stages from all other gadoids, in order to avoid confusion with closely related species; and one of my earliest tasks, as an oceanographer, was to describe the development of the principal gadoids (Johs. Schmidt 1905, 1906, 1907).

In the Icelandic waters, I have for some years been able to follow the drift of the pelagic cod fry (Johs. Schmidt 1904, 1909 etc.). The growth also is pretty well known in the main, (Johs. Schmidt 1904, Bj. Sæmundsson 1923). As regards the migrations of adult and adolescent cod, illustrated by marking experiments, important information is to be found in works by Johs. Schmidt (1907) and Bj. Sæmundsson (1923), while their migrations in the Faroe area have been dealt with by A. Strubberg (1916) on the basis of our extensive marking experiments in those waters.

On my first cruise to Iceland in 1903, with the research vessel »Thor«, then belonging to the Danish Commission, I succeeded in procuring the most essential biological and hydrographical data for a general understanding of the great Icelandic cod fisheries.

A full report of this work was published by me in 1904. As this report

only appeared in Danish, and has moreover, been out of print for some years past, I think it well to give here a brief summary of the principal results.

The hydrographical conditions in Iceland waters are highly characteristic, and of the greatest biological importance to all the principal food-fishes with which our Committee is concerned.

At the time when most of these food-fishes spawn, i. e. in spring and early

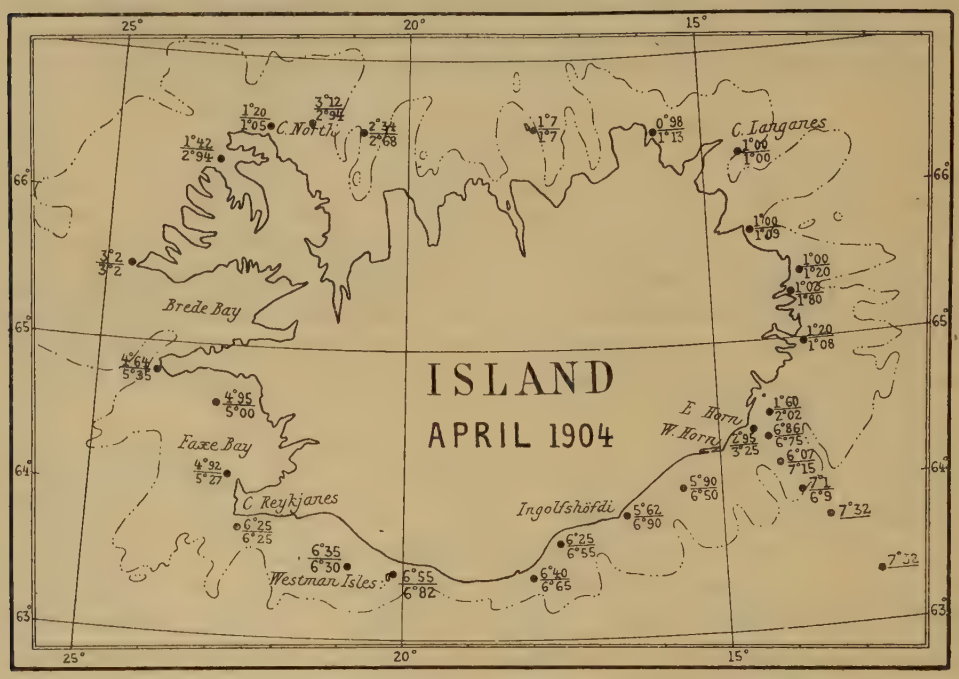

Fig. 59. Observations of temperature during the first voyage of the »Thor« round Iceland in April 1904. The upper numbers indicate the surface temperature, the lower the bottom temperature. The depths at which bottom temperatures were taken, always less than 200, usually less than 100 meters. (From Schmidt, 1909).

summer, the temperature of the water varies greatly on the different coasts of Iceland. The warmest water is found on the south and west coasts; the coldest on the east and north coasts. This is shown in several of the charts which I have published from time to time, e. g. chart fig. 5, p. 119, for the month of April 1904, in the Report in Procès-Verbaux, Vol. X 1909 (see fig. 59 in this Report), and the charts in this Report figs. 60 and 61 (for June 1924). All these charts show that there exists a pronounced hydrographical boundary off the S-E point of Iceland.

In 1903 and 1904, I circumnavigated Iceland several times on board the »Thor«, making hauls with pelagic nets, and observed the very striking fact that the eggs and tiny larvæ of the cod and most other food-fishes (haddock,

coalfish, whiting, ling, herring, and most of the principal flatfishes) were met with *en masse* in the warm water off the south and west coasts. They were lacking, however, or very scarce, in the colder waters of the east and north coasts.

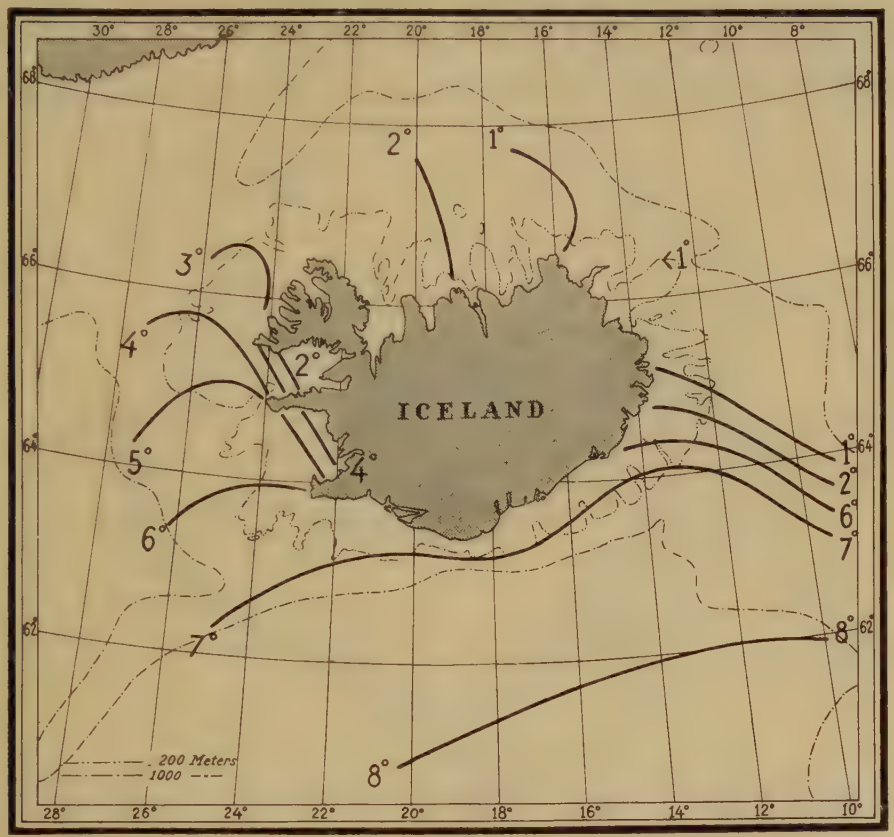

Fig. 60. The temperature at a depth of 50 meters during the spawning time of the principal gadoids (spring). The difference in temperature at 50 and 100—200 meters is but small at this time of year. (Prepared by Dr. J. N. Nielsen. After Schmidt, 1909).

From this I concluded that the cod and other food-fishes mentioned spawn, for the most part, only on the south and west coasts, and but little, or not at all, on the east and north coasts[1]).

[1]) It was also found that certain other species of fish only spawned in the cold water, (e. g. *Agonus decagonus* and *Triglops Pingelii*) while others again, as for instance the Long rough Dab *(Drepanopsetta platessoides)* had their spawning grounds both in the warm and in the colder water (see Johs. Schmidt, 1904, p. 48 ff.)

This discovery enabled us at once to understand the biological aspect of the great Iceland fisheries, in which the cod has from time immemorial played a leading part. We had now an explanation of the distribution of the great cod fisheries in regard to time and place.

We could understand now, why the spring fisheries, the most important of all, begin on the south coast of Iceland, where the yarmest water is found,

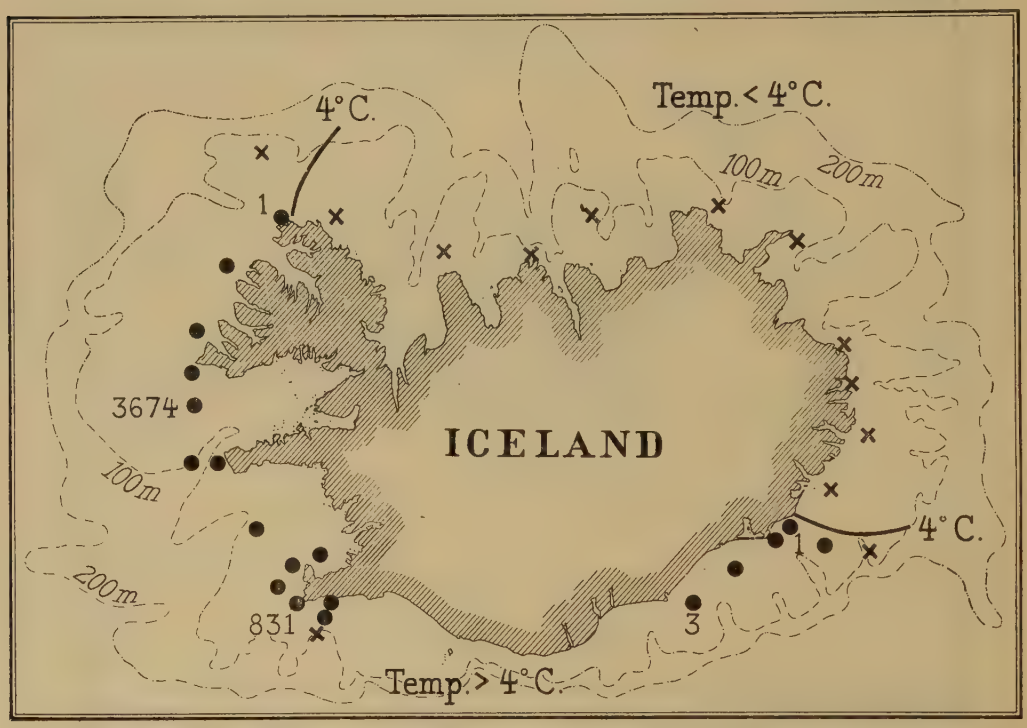

Fig. 61. Distribution of pelagic cod fry. »Dana«. June 1.—9. 1924.

• Postlarval stages of cod *(Gadus callarias)*; number of specimens per 15 minutes' haul with 2-m net indicated at a few stations. × no specimens taken.

and why this spring fishery — in contrast to the cod fishery in the colder parts of the Icelandic waters — was based almost exclusively on ripe fish concentrated there for the spawning.

Later in the summer, the masses of spent cod disperse throughout the greater part of the Icelandic waters, including the coldest portions, where the temperature, rising as the season advances, occasions a general flourishing of marine life, not least of pelagic forms.

In 1904, at my request, charts were made by the Fishery Inspection showing the position of cod-fishing sailing vessels of Icelandic, Faroese, Norwegian and French nationality. From these it appeared that the fleets during summer — in

contrast to their concentration in the spring — lay scattered about off the north-west, north, and east coasts. And at the same time, our fishing experiments from the »Thor« showed that practically all the cod found here were either immature or spent.

I have, since 1903, frequently investigated the distribution of pelagic fry off the coasts of Iceland during the summer (July-August). At this season,

Fig. 62. Distribution of pelagic cod fry. »Dana«. August 8.—14. 1925.
• Pelagic stages of the 0-group of cod *(Gadus callarias)*; 30 minutes' haul with 2-m net.
× no specimens taken.

we find a very different state of things from that encountered in the spring, when the pelagic young of cod, haddock etc. are only met with on the south and west coasts. In summer, the young fry, which have now increased in size, are found mainly on the north and east coasts (cf. chart for August 1925 and chart for June 1924 (figs. 62 and 61), and the more detailed charts for 1904 and 1905 in Procès-Verbaux Vol. X, 1909, Charts IX—X.)

In late summer, we find but few pelagic postlarvæ on the south and west coasts; they have now either moved down to the bottom as bottom stages, or drifted northward and east with the powerful north- and eastward summer current along the west and north coasts (the current around Iceland moves mainly in a clockwise, or anticyclonic direction).

The prevailing conditions of temperature and current lead to a distribution of the cod fry round all the coasts of Iceland; also, be it noted, to those parts where the species, practically speaking, does not spawn at all. A point of particular interest also, is the fact that hardly any other water in the world can show such great quantities of small cod, of the I-group, as the cold fjords on the east coast (e. g. the Seydisfjord and Eskifjord). The young cod here grow up in the cold water, making, apparently, no migrations of any great extent; but their growth is far slower than that of their contemporaries which sought bottom on the south and west coasts. They do not therefore attain maturity so early as these; but, when once mature, they seem, judging *inter alia* from our marking experiments, to leave the cold waters where their earliest years were spent, and move to join their companions of the south and west coast, and spawn there themselves.

From the fishery point of view, this great congregation of small, growing cod on the north and east coasts and in the fjords there is undoubtedly of very great importance, as they are here far better protected against destruction by the trawl fishery, which, from the nature of the bottom and other conditions is far less intensive than on the south and west coasts. As a matter of fact, the cod have, in the colder waters of the Icelandic area, a natural refuge, which is probably far more effective as a safeguard against overfishing of the stock than any protective measures on the part of man could ever be.

This, very briefly, was the general life-history of the Iceland cod, as revealed by investigations made by the Danish Commission and by cand. mag. Bj. Sæmundsson of Iceland.

The abundance of the fish in these waters, and the relative clarity of the principal hydrographical features, have rendered it easier, perhaps, here than elsewhere — as in the North Sea, for instance, where the hydrography is more complicated — to obtain a general survey of the life history of the cod.

This general survey, however, showing the life history of the cod in the most important part of the »North-Western Area Committee's« sphere of operations, is no longer sufficient for the purpose which the Committee has in view.

It has provided the necessary biological and physical foundation for — or introduction to — the future work of the Committee. But in the future, we cannot rest content with an ordinary generalised survey; for the life-history of the cod in this area consists of a long series of individual life-histories, fluctuating from place to place and from year to year. And here we come to the essential point; it is these fluctuations which we have to study in the future, as far as our means allow — and they are but small in proportion to the greatness of the task. Our immediate aim therefore, both as regards the cod and the other fishes on our programme of investigations, should, in my opinion, be to ascertain as far as possible the composition of the stock from

year to year, and endeavour to arrive at an understanding of the causes responsible for those fluctuations, which we already know to exist. This would best further the economical interests of the fishery, which are and should be the basis of our work.

Generally speaking, it is by no means easy to discern these fluctuations in the composition of the stock of cod from year to year. It can be done in different ways, according to circumstances. I will give a simple example, on a small scale.

Having only age-determined material available from 1924 and 1925, I will include a number of measurements from the years before the war, procured by the Danish research vessel »Thor«.

This material was obtained in the eastern and northern fjords by the use of Danish eel-handseine, an implement well suited to the capture of small cod, and one which I have found most useful during my many years of work in Iceland waters. It works excellently with young gadoids up to abt. 30 cm. length, and we have often taken several thousand fish per haul in the fjords on the east coast of Iceland.

As all the gadoids grow but slowly in this cold area of the Iceland waters, it is nearly always easy to separate the 0-, I- and II-groups by simple measurement. We may here disregard the 0-group, which do not appear in the East-Iceland fjords until the latter end of the summer. Our method then, consists in counting up, for each haul, the number of specimens of the I-group, and comparing with the number of older fish, which really amounts to the II-group + some few older specimens.

The hauls were made for the most part in summer, from May to August, and included, besides cod, young gadoids of the following species: Coalfish *(Gadus virens),* Haddock *(G. aeglefinus)* and Whiting *(G. merlangus).*

What we wish to ascertain, then, is the relative frequency of the I-group fish. This is measured, either by the number of specimens of this group in proportion to those of the II-group and the few older fish of the same species, or by the number of cod belonging to the I-group compared with the no. of specimens of this group in the remaining species.

The tables 1 and 2 show, in the first place, that great fluctuations may occur from year to year in the quantity of I-group cod and of the other species. But we find also, that whichever way we measure, we arrive at the same result, namely, that the years 1905 and 1924 were relatively bad years for the I-group cod.

There seems, then, to be some reality underlying this agreement. As to the cause, it is difficult to say anything for certain. It may probably be that the drift of pelagic cod fry to the north and east coasts was not so successful during the years 1904 and 1923; but as to the further cause why this should be so, we can say nothing, at any rate for the moment.

Table 1.

Quantity of Cod of the I-group in proportion to quantity of the II-group (and older fish).

	North-Iceland			East-Iceland		
	Total No. of specimens	I-Gr. No. of specimens	I-Gr. %	Total No. of specimens	I-Gr. No. of specimens	I-Gr. %
1903.....	376	375	**99.7**	7060	6030	**85.4**
1904.....	1840	1541	**89.2**	8254	7842	**95.0**
1905.....	1121	224	**20.0**	1313	783	**59.6**
1908.....	146	122	**83.6**	1647	1537	**93.9**
1924.....	811	460	**56.7**	1005	593	**59.0**
1925.....	—	—	—	2200	2133	**97.0**

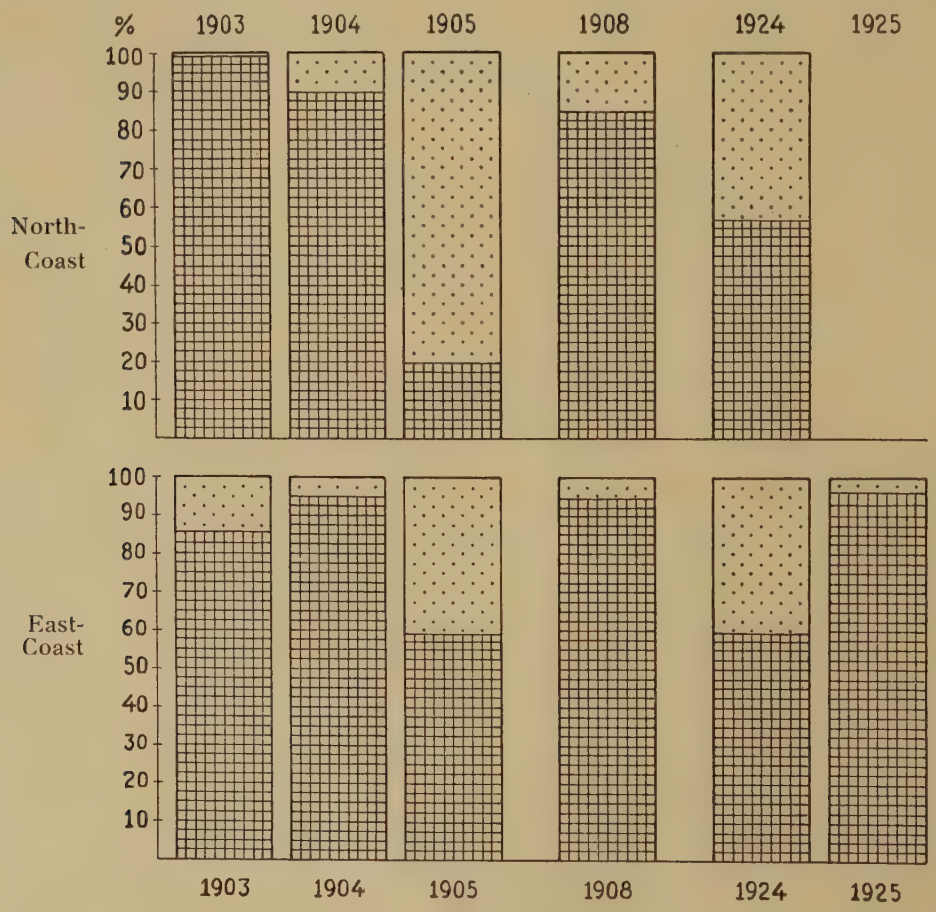

Fig. 63. Cod (*Gadus callarias*, L.). Percentage of I-group in total no. of cod (excl. 0-gr.)

I-group. > I-group.

Table 2.

Quantity of Cod of the I-group in proportion to quantity of the I-group of other species. East-Iceland 1903—05, 1908, 1924—25.

East-Iceland	1903		1904		1905		1908		1924		1925	
Species	No. of specimens	%	No. of specimens	%	No. of specimens	%	No. of specimens	%	No. of specimens	%	No. of specimens	%
Gadus callarias	6030	**85 78**	7842	**98.55**	783	**22 25**	1537	**55.55**	593	**15.29**	2133	**99.67**
— *aeglefinus*	0	**0.00**	3	**0.04**	2068	**58.77**	1230	**44.45**	0	**0.00**	0	**0.00**
— *virens*	794	**11.29**	112	**1.41**	644	**18.30**	0	**0.00**	3285	**84.71**	2	**0.09**
— *merlangus*	206	**2.93**	0	**0.00**	24	**0.68**	0	**0.00**	0	**0.00**	5	**0.24**

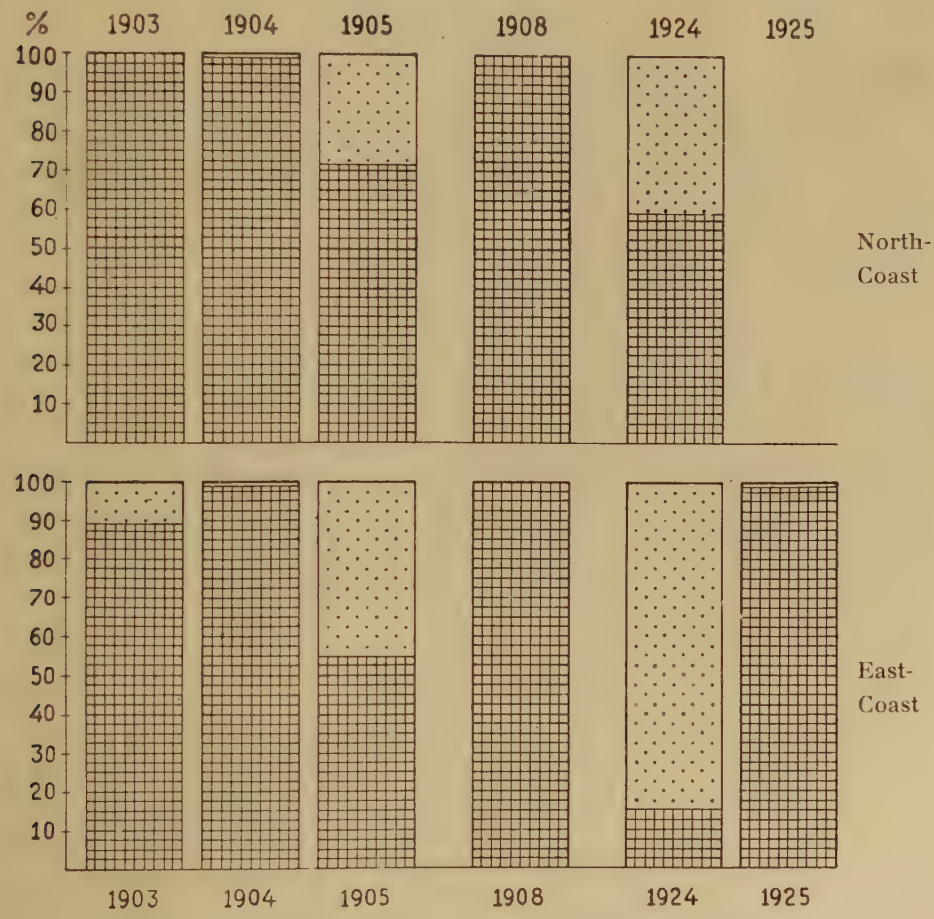

Fig. 64. Relative quantity of I-group, Cod (*Gadus callarias*, L) and Coalfish (*Gadus virens*, L).

Cod. Coalfish.

Finally, I would refer to the graphs, figs. 63 and 64, the former showing percentage of I-group fish in the total no. of cod, and the latter showing relative quantity of I-group fish among cod and coalfish *(Gadus virens)*. On comparing the north coast with the east coast, we find an unmistakable agreement between the two; the graphs showing that the years 1905 and 1924 were, on both coasts, different in this respect from the other years considered.

Such investigations as these should be continued in the future; they are easy to carry out, and will be of still greater interest when we have reached a point where it is possible to compare them with the results of trawling experiments, in which quantities of older cod are also included.

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— The pelagic postlarval stages of the Atlantic Species of Gadus I. Medd. Kommissionen for Havundersøgelser. Fiskeri Bd. I, No. 4, 1905. II. ibid. Bd. II, No. 2, 1906. See also Bd. I, No. 8. 1905, Bd. II, Nos. 3, 7, 9, 1906—07.

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Preliminary Report on Iceland Haddock

from

Danish Data referring to Years 1903—1924.

By

HAROLD THOMPSON
Aberdeen.

1903: For this year only four trawl hauls and ten lining experiments are recorded and the results, judged from the figures alone, are not important, and refer chiefly to the Eastern part of the Island. Here, judging from our previous scale-size results, the 1899 group (4 years old) and 1897 group (6 years old) clearly predominated, with mean sizes of 40.5 and 51.0 cms. respectively. The 1900 group (3 years old) appeared to predominate in the south, with a mean size of 46 cms.

1904: Figures relating to 75½ hours' trawling are available for this year. The 1903 group stands clearly forth in the south, with a mean size of 17.5 cms., but it is not recorded in any number from elsewhere. Along with it the 1898 (?) group appears in quantity, with a mean size of 57.5 cms. However, in North and East it is probably the 1899 group (5 years old) which predominates.

1905: Figures for 42 hours' trawling are given. Reliable age distributions for the 1904 brood (which was the most successful for a decade or so at Iceland) appear for the South and East regions. The sizes are:

South:	17.8 cms. (June)	East:	14.5 (May)
			16.0 (July)
			17.0 (August)

Along with this group appears that of 1903 again in the south, now 30½ cms. in average length, and possibly also the 1898 group. In the North the 1903 group is also prominent (mean size 29.5 cms.)

Hence it seems that the growth rate is greatest in the south, less in the north, and still less in the east. Again the success of any particular year brood is not general around the Island, but may be confined to say, south and west, south and east, or north and east etc. The year groups were distributed somewhat as follows:

South	1904 [1])	1903	1900	—	1898	—
North	—	1903	—	1899	—	—
East	1904 [1])	—	—	1899	—	1897

[1]) Especially good.

1908 & 1909: Excellent data, supplemented by copious scales, are given for the years 1908—09 in Faxe Bay. All the scales were aged (sometimes that could be done with certainty without reference to the scale) and then the total figures were subdivided among the age groups accordingly, with the following group frequency results:

Year Brood	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896
Frequency (1) 1908	1	580	381	636	1039	651	147	56	43	55	21	3	2
(2) 1909	3	3249	1948	669	4023	988	106	98	146	78	51	6	0
Total Frequency	4	3829	2329	1305	5062	1639	253	154	189	133	42	9	2

From these figures it would appear that the most successful year was 1904, but that 1907, 1906, 1903, 1900, 1899 and 1898 were fairly productive. The leanest years were evidently 1908, 1905, 1902 (?), 1901 (?), and perhaps 1897 and 1896.

The sizes attained by the various age groups compared as follows:

Age	0	1	2	3	4	5	6	7	8	9	10	11	12
1908	6.5	17.7	32.0	42.1	51.4	59.1	63.9	67.3	70.7	75.9	76.3	88.7	85.0
1909	—	—	32.8	42.9	51.4	51.7*	61.1	68.3	72.2	73.4	76.1	79.3	79.7

* This is the most noticeable point of disagreement in the figures, and is not easely to be explained. Why the 1904 group should only have grown 0.3 cms. in a year is a problem — only partly explained away by the great diminution in the proportion of females, 52 per cent. in 1908, only 37 per cent. in 1909. It is really useless to theorise about the efflux of the larger fish of the group or an influx of smaller fish from, say, the east.

The calculated sizes from 1904 brood scales (1908 and 1909) may throw light on this.

1924: For this year the most representative data are given, referring to work done all round the Island. The year groups distributed themselves as follows:

1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912
2	3224	6227	875	84	4	29	14	14	12	3	1	—

Hence year 1922 is outstanding, while 1923, 1921 and possibly 1918, 1916 and 1915 were good. If the figures for the north be taken independently, we find:

1923	1922	1921	1920	1919	1918
14	1247	550	76	0	8

from which it appears that 1922, 1921, 1920 and possibly 1918 were the best years — but that 1923 was not (contrast with N. Sea). From this we might argue that the main drift of Haddock larvae was to the north in 1920 and 1921, to the west in 1923, and to both in 1922 and 1918.

The sizes attained by the age groups were:

Age	0	1	2	3	4	5	6	7	8	9	10	11
South	6	19.5	33.1	45.9	55.0	52.8	57.7	62.7	66.8	68.3	69.7	73.0
North.....		15.8	26.5	35.9	46.2		55.2					
East		14.5										

There seems to be an absence of the oldest fish except in the south. Growth in the south is greater than that in the north by:

3.7 6.6 10.0 8.8 ? 2.5 cms. in years 1—6 respectively.

Hence the maximum difference is established by the end of year 3, when the difference again dwindles. This might argue a movement towards a general spawning (mixing) ground after the 3rd feeding season.

In general it is clear the young fish are found mostly in shallow water and older fish in deeper water. Most 1-year olds were taken in 1904, in from 5 to 30 metres depth (in the East chiefly).

So far as the rather limited Scottish material for recent years goes, agreement is found in the predominance of the 1922 and 1921 broods, and the rarity of occurrence of the 1920 and 1919 broods. Among the older fish those of 1918 and 1916 are most frequently encountered.

From 1924 samples taken from commercial vessels at Aberdeen it would appear that the »Dana« captured a relatively high proportion of small fish.

Contributions to the Life-History of the Icelandic Plaice.

By

Å. Vedel Tåning.

Introduction.

The following preliminary investigations as to the age-composition of the stock of plaice in Iceland waters are based on material procured in 1924 during the cruise of the »Dana« to the Faroes and Iceland, under the leadership of Prof. Johs. Schmidt.

The material comprises, first of all, a large number of otoliths representing hauls made inside and outside the territorial limit in Faxe Bay; these hauls are all from stations of practically uniform depth (30—37 metres). In addition, there are some samples from Skiálfandi Bay on the north coast of Iceland; these are from depths of 0—50 metres. A few supplementary samples from other localities have also been included.

For comparison af the sizes of plaice taken in different years, and at different localities, we have also considered some records of trawl catches (made with a 50-ft. otter trawl) and a few hauls from previous years made with the Danish seine (»Thor« 1903 and following years).

We shall not here enter into any discussion of the number of abnormal and indeterminable otoliths, or special investigations as to different growth in different years as indicated by the otoliths The otolith material from the different localities varies somewhat in regard to distinctness of the growth rings, and a large proportion of the otoliths from the 3200 specimens investigated had to be polished, as wit houtthis, it is often impossible to be quite sure of the innermost rings. The »winter-rings« in plaice from Iceland are, as also observed by G. T. Atkinson in plaice from the Barents Sea, mostly very sharp and narrow; this of course greatly assists the work of age determination, but may on the other hand prove a hindrance in determining whether a ring is secondary or not.

The material being mainly from shallow water, comprises few specimens of ten years or more: these have therefore been taken under one head in the tables. The oldest fish in our material is hardly more than abt. 15 years old,

but since all our specimens are, as mentioned, from shallow water, this tells us nothing as to the age which plaice can attain in Iceland waters.

Age determinations based on otoliths of plaice from Iceland have hitherto been carried out only to a slight extent, and the only extant work on the subject is a brief report by K. Jessen (1909), dealing with material collected in 1908 from the west and north-west of Iceland. The fish were taken mainly in coastal water, at depths from abt. 0—25 metres in various fjords during the months of July and August.

The average lengths of the various year-classes for the different localities lie within the following limits:

Age-group I:	7.1— 8.5 cm	V: 27.8—35.7 cm	VIII: 34.0—45.0 cm
II:	10.6—15.0 -	VI: 26.0—38.3 -	IX: (49.0 -)
III:	17.0—27.6 -	VII: 29.0—40.8 -	X: (41.0 -)
IV:	24.5—31.5 -		

Of the first 7 groups, some 2000 specimens were investigated, of the last 3 only 20.

From this it appears, in agreement with what we found in Faxe Bay in 1924, that the West Iceland plaice move out from the shallow water at an age of abt. 7—8 years; the writer also points out that the growth of plaice here, in West and North-West Iceland, varies from one fjord to another (growth in Skutilsfjord and Dyrafjord more rapid than in Havnefjord, Patriksfjord and Ønundarfjord).

In order to illustrate this difference in growth for a few localities and also to show that the investigations dealt with in this small paper cannot be taken as generally valid for growth in West and North Iceland, we give, in the graph fig. 65, p. 154, average lengths of the five youngest year-classes taken in eel-hand-seine at the different localities.

A. Faxe Bay (Havnefjord) . .	13.—14. June 1924.	Depth 0—11 m.
B. Patriksfjord.	7. June 1924.	» 0—5 -
C. Skjálfandi Bay (Husavik) .	26. July 1924.	» 0—6 -

The difference in time of year between the two first catches and the last one is doubtless of negligible importance, as Skjálfandi Bay has its »summer« later than the western part of Iceland. It will be noted that the growth in Patriksfjord is markedly inferior to that of both the other places, though we might expect to find the growth here more resembling that of Havnefjord, in contrast to that of the north coast.

Since, then, the stocks of plaice in the various fjords and bays evidently differ greatly in regard to growth, it is obvious that investigation of the separate stocks will be needed before we can understand the composition of the stock spawning in the west and south, which has been proved by marking experi-

ments to be a mixed stock composed of the numerous stocks all round the coast (SCHMIDT 1907, SÆMUNDSSON 1913).

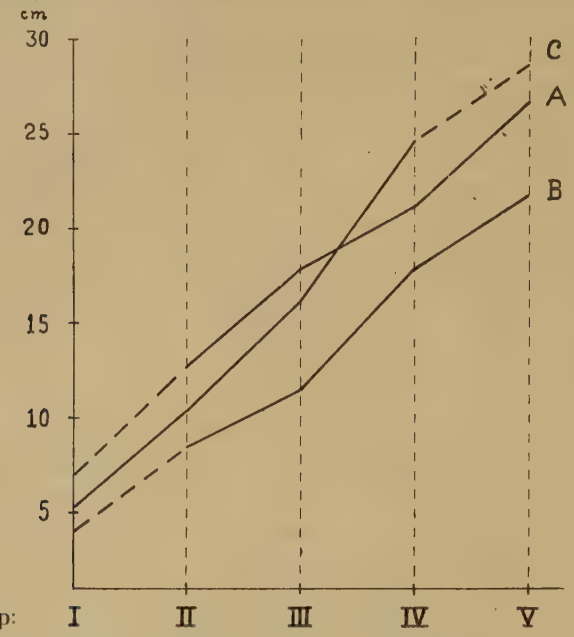


Fig. 65. Average length of the different age-groups of plaice from: A. Faxe Bay (Havnefjord) 0—11 m., B. Patriksfjord 0—5 m., C. Skjálfandi Bay 0—6 m.

On the subject of Iceland plaice generally, we would here refer to BJ. SÆMUNDSSON: Oversigt over Islands Fiske (1909) in which will be found a brief summary of our knowledge in regard to this species in Iceland waters, with a list of works dealing with this subject up to 1909.

Age-investigations.

I. Faxe Bay. West Iceland.

As already mentioned, the main point in these investigations was to arrive at a survey of the age-composition of the stock of plaice inside and outside the territorial limit in Faxe Bay, which is one of the most intensively trawled areas in Iceland waters. Our samples, taken with a 50-ft otter trawl with extra cod-end, are as follows:

Extra-territorial: Position: 64° 08′ N., 22° 23′ W.
Depth: 33—37 metres.
St. 2129. 11.—12. June. Trawling time 12 hrs.
156 plaice.
St. 2139. 21.—25. June. Trawling time 39 hrs.
583 plaice.

Intra-territorial: Position: 64° 04′ N., 22° 35′ W.
Depth: 30—36 metres.
St. 2142. 25.—27. June. Trawling time 17 hrs.
2215 plaice.
St. 2170. 5.—7. July. Trawling time 15¾ hrs.
1281 plaice.

Out of the material from these extra- and intra-territorial stations, all that from St. 2129 and 2139, with the greater part of that from St. 2142 has been subjected to age-determination. In the case of St. 2142, we have not age-determinations of the entire material of most frequently occurring lengths, but have calculated the whole on the basis of the age-determined specimens, amounting to at least 60 specimens for each cm.-group.

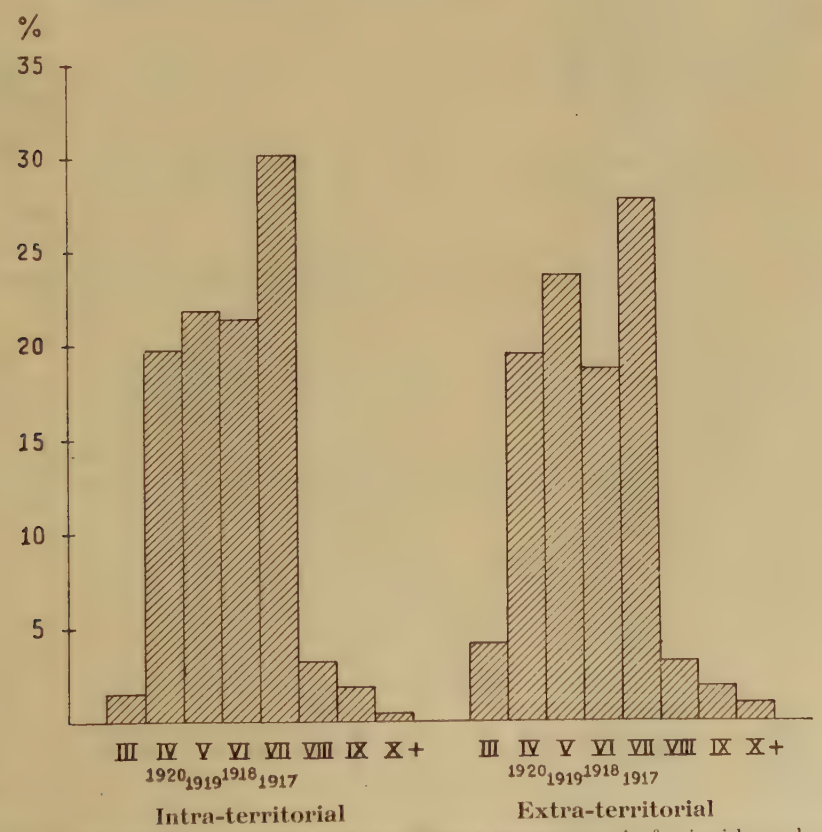


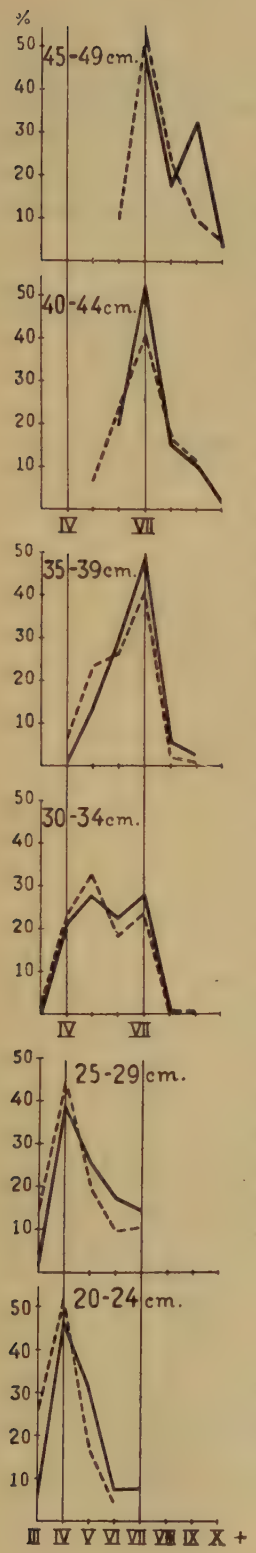
Fig. 66. Graph showing the occurrence of the different age-groups in %, inside and outside the territorial limit. Faxe Bay, 1924.

About 6—11 % of the material in the different samples had to be discarded as undeterminable (abnormal, uncertain etc.).

Table 1.

Faxe Bay. June 1924. **Intra-territorial.** **Extra-territorial.**

Year Brood & Age-group:	♂			♀			♂ + ♀			♂ + ♀			♂			♀			Year Brood & Age-group:
	No. of Specimens	Average length cm.	Range of Variation	No. of Specimens	Average length cm.	Range of Variation	No. of Specimens	Average length cm.	Range of Variation	No. of Specimens	Average length cm.	Range of Variation	No. of Specimens	Average length cm.	Range of Variation	No. of Specimens	Average length cm.	Range of Variation	
1923 I																			I 1923
1922 II																			II 1922
1921 III	18	**24.94**	19–30	10	**24.30**	19–27	*28*	*24.61*	*19–30*	*29*	*25.31*	*16–32*	18	**26.61**	16–32	11	**25.64**	20–29	III 1921
1920 IV	229	**27.88**	20–34	160	**28.43**	18–35	*389*	*28.19*	*18–35*	*137*	*29.61*	*19–38*	62	**28.71**	20–36	75	**30.20**	19–38	IV 1920
1919 V	243	**30 57**	20–39	187	**30 99**	20–39	*430*	*30.76*	*20–39*	*166*	*32.68*	*22–41*	94	**33.01**	22–41	72	**32.22**	22–40	V 1919
1918 VI	250	**32 98**	22–41	171	**33.56**	23–43	*421*	*33.20*	*22–43*	*131*	*34.96*	*24–46*	68	**34.88**	28–43	63	**35.05**	24–46	VI 1918
1917 VII	321	**34.06**	23–49	273	**35.37**	24–50	*524*	*34.67*	*23–50*	*195*	*36.14*	*27–51*	89	**35.88**	28–51	106	**36.36**	27–47	VII 1917
1916 VIII	26	**37.65**	33–44	37	**39.62**	31–52	*63*	*38.81*	*31- 52*	*22*	*40.59*	*32–49*	7	**39.71**	32–46	15	**41.00**	33–49	VIII 1916
1915 IX	17	**38.94**	35–47	20	**44.10**	38–53	*37*	*41.73*	*35–53*	*13*	*40.29*	*33–45*	9	**39.89**	33–45	4	**41.50**	38–44	IX 1915
191 +X+	2		43–53	5		40–61	7		*40–61*	7		*49–60*	2		51–55	5		49–60	X+1914+
Indet.	123			119			*242*			*43*			23			20			Indet.
Totals	1229			982			*2211*			*743*			372			371			Totals



In Table 1, p. 156, and fig. 66, p. 155, will be found a survey of the age-composition for the intra- and extra-territorial areas.

From this it will be seen, first of all, that we find the same year-classes forming the bulk of the stock both intra- and extra-territorially (groups IV—VII, i. e. year brood 1917—20); and further, that the percentage of the different year-classes in the intra- and extra-territorial areas is practically the same.

Extra-territorially, the 1919 brood (the V-group) and intra-territorially, the 1918 and 1917 brood (VI—VII-groups) will be found somewhat more abundant than on the respectively opposite side of the territorial limit. It is not the oldest year-classes which are most richly represented in the extra-territorial area, the slight difference is therefore not due to migration of the older fish to the more open waters of the bay [1]).

The curves in fig. 67 showing the percentage of the different age-groups at 5-cm. intervals from 20 to 49 cm. shows that the age-composition at the different lengths is also very nearly the same inside and outside the territorial limit.

The catch per trawling hour outside the territorial limit is greatly inferior to the figure for intra-territorial hauls (14.5 specimens as against 106.8) and the average length of the fish is greatest outside the territorial limit: i. e. 33.92 cm. as against 32.38 cm. inside. This difference in size is plainly apparent in all the dominant age-groups, as may be seen, partly from Table 1, and also from the graph fig. 68, showing average lengths for both sexes together from the two areas. It will be noticed that the difference between average length of the principal groups inside and outside the territorial limit

[1]) Any influence of the depth is, as already mentioned, eliminated by the fact that the intra- and extra-territorial stations were taken at points were the depth was the same (33—37 and 30—36 m).

Fig. 67. Curves showing the percentages of the different age-groups at 5-cm. intervals.
——— Intra- - - - - - Extra-territorial. Faxe Bay. 1924.

lies between 1.42 and 1.92 cm., (IV: 1.42, V: 1.92, VI: 1.76, VII: 1.47 cm.) i. e. in all groups answering well to the difference of 1.54 cm. in average length for the whole material from the two areas.

Taking the sexes separately, we find the same thing. Outside the territorial limit, the ♀♀ are 1.06 cm. and the ♂♂ 1.73 cm. longer than inside, as will be seen from the following:

	Average length Extra-territorial	Average length Intra-territorial	Difference
♀♀	$A_{372} = 34.26$ cm	$A_{1568} = 33.20$ cm	1.06 cm.
♂♂	$A_{365} = 33.49$ -	$A_{1919} = 31.76$ -	1.73 -

The males, then, are of the same average length outside as the females inside the territorial limit

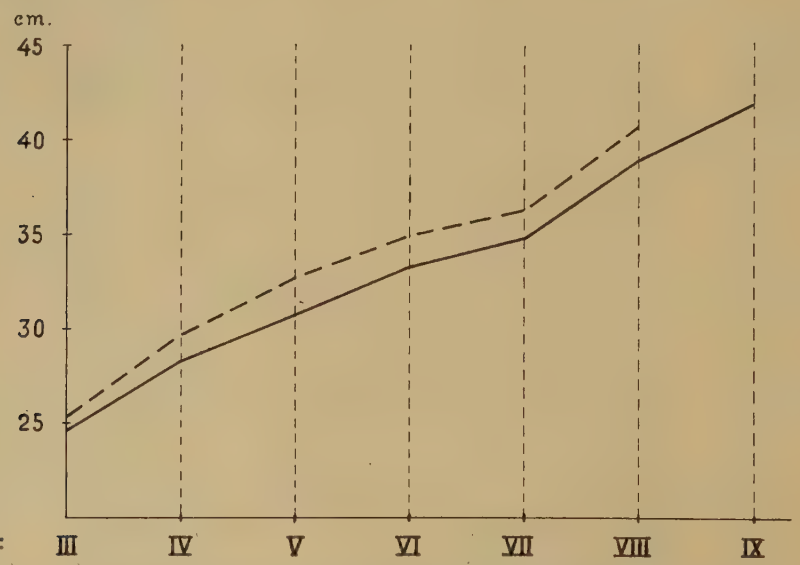


Fig. 68. Curve showing average length of the different age-groups. ——— Intra- ------ Extra-territorial. Faxe Bay 1924.

The four dominant age-groups all show, for both sexes, a greater average length outside than inside the territorial limit:

	IV-gr.	V-gr.	VI-gr.	VII-gr.
♀♀	1.77 cm[1])	1.23 cm	1.49 cm	0.99 cm
♂♂	0.83 -	2.44 -	1.90 -	1.82 -

It will be seen, then, that this greater average length of the extra-territorial stock must be due, not to any predominance of the

[1]) Difference in cm. between average length outside and inside the territorial limit.

older year-classes, but to the fact that the principal year-classes (groups IV—VII) are all represented by somewhat larger fish in the extraterritorial area than we find inside the territorial limit.

This fact suggets either that the larger (not the older) fish migrate to more open water in Faxe Bay, or that the stock here, being less densely packed, finds better conditions for growth than inside the territorial limit.

The numerical distribution of the two sexes inside and outside the territorial limit presents some features of interest.

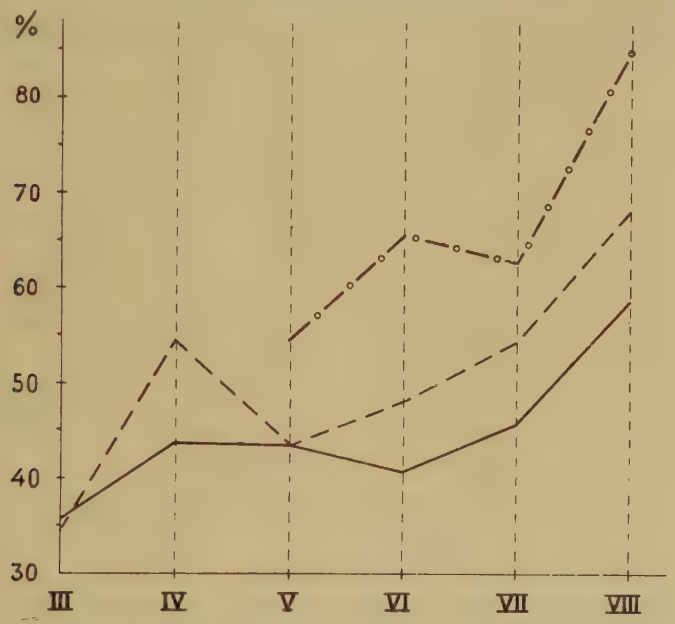


Fig. 69. Curves showing the percentage of females in the different age-groups. ——— Intra- – – – – Extra-territorial. Faxe Bay 1924. —o—o— Skjálfandi Bay 1924.

Outside, the sexes are more or less evenly represented (365 ♂♂ against 372 ♀♀); inside, however, the males predominate, (1919 against 1568). This may of course contribute to the difference between average lengths inside and outside for the whole material, as the males are smaller than the females; but as we have seen in the foregoing, the difference between average length inside and outside the territorial limit is not principally due to an accumulation of males inside the limit, but to the fact that all the dominant year-classes are larger outside than inside (applicable to males as well as females, see table 1). Finally, fig. 69 shows the percentage of ♀♀ and thus of ♂♂ in the principal age-groups for the respective areas.

The foregoing examination of material from a couple of stations in Faxe Bay can only be regarded as the first step towards a thorough investigation

of the waters concerned, and affords but a fragmentary view of the general growth conditions there prevailing. From shallower water, we have from 1924 the small sample previously referred to (Havnefjord, mid June). It affords some slight contribution to the determination of average length for the II- and III-groups, and shows, moreover, that the portion of the IV-group found at the two intra- and extra-territorial stations only comprises the larger individuals of this group.

Without entering into any discussion of this small sample in relation to the other material, we may give the following figures:

Age-group	No. of spec.	Av. length in cm.	Range of variation
I	1	7.00	7 cm
II	32	**12.87**	9—19 -
III	36	**17.89**	10—24 -
IV	31	**21.03**	13—28 -
V	9	26.56	23—29 -
VI	4	29.75	26—32 -
VII	5	28.00	23—31 -

II. Skjálfandi Bay. North Iceland.

We have from here, as already mentioned, a series of samples taken at the end of July 1924, in eel-seine and 50-ft. otter trawl at depths from 0—50 metres. The eel-seine sample, taken from a depth of 6 m. to land, is from Husavik (66° 02.5′ N., 17° 18.5′ W.) the other hauls being from the trawling grounds on the western side of the bay (65° 59.5′ N. 17° 13′ W., 66° 00′ N. 17° 13′ W., 66° 01′ N. 17° 13′ W., 66° 01′ N. 17° 30′ W.). The two samples analysed are from 7—10 and 20—50 m depth; the latter of these, being taken inside the territorial limit, may be compared with a corresponding one from Faxe Bay. Owing to difference in depths, hydrographical and other conditions, however, we should be careful not to attach overdue weight to any differences or similarities between the two places. But it is of importance for the fishery to note that the catches here amount to 53,2 specimens = 43.8 kilos. per trawling hour, whereas the corresponding values for Faxe Bay inside the territorial limit are 106.8 spec. = 44.1 kilos. per trawling hour.

Table 2, pp. 162—163, shows the figures for the material investigated from Skjálfandi Bay.

A comparison between the age composition of the stock in Faxe Bay and that in Skjálfandi Bay, taking the hauls from 20—50 metres and those from the Faxe Bay stations above referred to, shows that in the latter, the IV—VII-groups are more or less evenly represented, whereas in Skjálfandi Bay, the VI—VIII-groups are especially predominant. This is conspicuously evident from the curves in fig. 70.

In Skjálfandi Bay as a whole the stock of plaice is displaced nearer to the coast than in Faxe Bay.

The average size of trawled fish in Skjálfandi Bay is greater than that for Faxe Bay at comparable depths in the present material. On comparing the four principal groups, IV—VII from Faxe Bay with those from Skjálfandi Bay — where, unfortunately, the IV- and V-groups are but poorly represented at 20—50 m. depth — we find that the corresponding groups are abt. $2^1/_2$—$4^1/_2$ cm. larger in Skjálfandi Bay. In other words, the superiority in size of the plaice from Skjálfandi Bay as compared with those from Faxe Bay at nearly the same depths is due not only to the fact that the stock in the northern waters consists of older fish on the whole, but also to the fact that the plaice of the same age-groups here are of larger size.

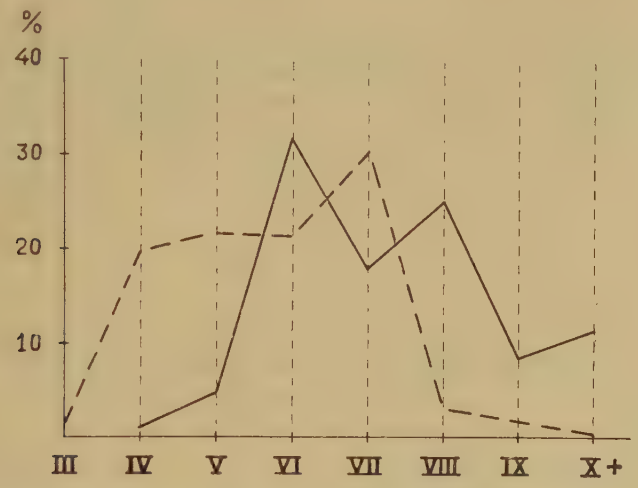


Fig. 70. Curves showing the percentage of the different-age groups in Faxe Bay ——— and Skjálfandi Bay ——— (Faxe Bay: intra-territorial, 30—36 m. depth; Skjálfandi Bay, intra-territorial, 20—50 m. depth).

	Faxe Bay (Depth: 30—36 m)		Skjálfandi Bay (Depth: 20—50 m)	
Age-group	♂	♀	♂	♀
IV	27.88 cm	28.43 cm	(33.00 cm)	
V	30.57 -	30.99 -	(33.20 -)	(34.33 cm)
VI	32.98 -	33.56 -	35.29 -	37.08 -
VI	34.06 -	35.37 -	38.50 -	39.81 -

It will be noted, however, from the curve in fig. 65 that the growth of the three youngest year-classes in Skjálfandi Bay is evidently slower at any rate than in Havnefjord (Faxe Bay) and it is apparently their more rapid growth after the 3rd to 5th year[1]) which gives the plaice of Skjálfandi Bay their advantage over those of Faxe Bay in point of size.

Table 2 shows the well known feature of larger and older fish out in

[1]) cf. Table 2 with Table 1.

Table 2.

Skjálfandi Bay. July 1924. 0—6 metres (Husavik—Eel-seine): 7–10 metres

Year Brood & Age-group.	♂			♀			♀ + ♂			♂			♀
	No. of Specimens	Average length cm.	Range of variation	No. of Specimens	Average length cm.	Range of variation	No. of Specimens	Average length cm.	Range of variation	No. of Specimens	Average length cm.	Range of variation	No. of Specimens
1923 I	—	—	—	—	—	—	*15*	*5.27*	*4— 7*				
1922 II	—	—	—	—	—	—	*141*	*10.30*	*6—14*				
1921 III	36	**16.36**	11—23	36	**15.75**	18—21	*72*	*16.06*	*11—23*				
1920 IV	18	**25.11**	21—31	19	**24.00**	16—29	*37*	*24.54*	*16—31*	5	[**26.40**]	22—35	5
1919 V					[**28.50**]	25—31	*4*	[*28 50*]	*25—31*	33	**29.33**	24—34	34
1918 VI	2	[**32.00**]	32	4			*2*	[*32.00*]	*32*	48	**34.54**	28—41	55
1917 VII										3	[**38.33**]	37—40	7
1916 VIII										3	[**38.00**]	36—41	5
1915 IX													2
1914 + X +													7
Indet.	2			1			3			4			9
Totals	58			60			**274**			96			124

deeper water: at depths from 0—6 m., the II—IV-groups predominate, at 7—10 m., the V—VI-groups, and at 20—50 m., the VI—IX-groups [2]).

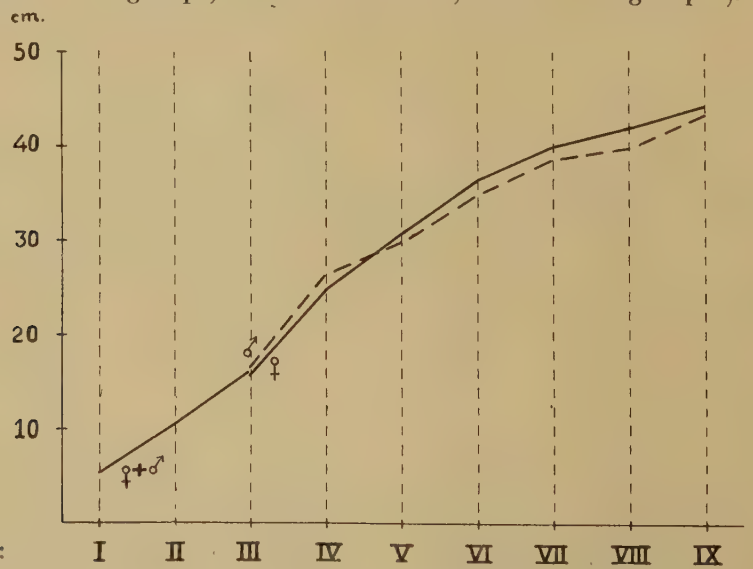


Fig. 71. Curves showing average length of the different age-groups (males and females taken together in groups I—II). Skjálfandi Bay 26.—27. July 1924.

[2]) It may be observed that the samples investigated hardly contained specimens over 15 years old; the majority of those entered under X + were ten-year-old fish, some 11—12 years, and a few older.

(Trawl): ♀ Average length cm.	♀ Range of variation	20—50 metres (Trawl): ♂ + ♀ No. of Specimens	♂ + ♀ Average length cm.	♂ + ♀ Range of variation	♂ No. of Specimens	♂ Average length cm.	♂ Range of variation	♀ No. of Specimens	♀ Average length cm.	♀ Range of variation	♂ + ♀ No. of Specimens	♂ + ♀ Average length cm.	♂ + ♀ Range of variation	Year Brood & Age-group
														I 1923
														II 1922
														III 1921
[27.20]	24—29	*10*	[*26.60*]	*22—35*	2	[33.00]	32—34				*2*	[*33.00*]	*32—34*	IV 1920
30.32	25—37	*67*	*29.82*	*24—37*	5	[33.20]	31—36	6	[34.33]	32—36	*11*	*33.82*	*31—36*	V 1919
35.16	30—40	*103*	*34.87*	*28 41*	26	35.29	32—39	50	37.08	28 47	*76*	*36.46*	*28—47*	VI 1918
[39.43]	37—41	*10*	[*39.10*]	*37—41*	16	38.50	36—46	27	39.81	36—44	*43*	*39.33*	*36—46*	VII 1917
[39.40]	35—43	*8*	[*38.88*]	*35—43*	9	[40.00]	37—42	51	41.80	36—48	*60*	*41.53*	*36—48*	VIII 1916
[43.00]	42—44	*2*	[*43.00*]	*42 44*	7	[42.86]	39—47	13	44.15	41—48	*20*	*43.70*	*39—48*	IX 1915
	47—63	*7*		*47—63*	1		44	26		41—54	*27*		*41—54*	X+1914+
		13			13			14			27			Indet.
		220			79			187			**266**			Totals

The I-group is very poorly represented. This group, however, seems in certain years to be far more abundant in proportion in shallow water; as in 1903 for instance, when eel-seine hauls abt. 1. July comprising abt. 2500 specimens contained abt. 1100 fish < 7 cm. These small fish doubtless belonged nearly exclusively to the I-group, there being a sharply defined limit at 7 cm. length, where the II-group must be supposed to begin.

In order to arrive at accurate average lengths for each age-group in the stock of the bay as a whole, we should require a far greater quantity of material, including also fish from still greater depths. This was unfortunately not available, but it will doubtless be of interest nevertheless to give here a curve showing the growth in an area which has not been very intensively worked by the trawl during the past ten years. Fig. 71 shows the average length of the individual age-groups, calculated from material collected as a whole; from the III-group onwards, the sexes are taken separately (cf. Table 2).

We may here add, that the growth in Skjálfandi Bay — as might be expected for the species in these waters — is evidently restricted to a shorter period of the year than in Faxe Bay, and that the individuals keep much closer together in their growth than is the case in Faxe Bay. In this latter water, the great majority of the variants in the different age-groups cover a range of abt. 15 cm., whereas in Skjálfandi Bay, the corresponding figure is only abt. 10 cm.

The proportion between males and females, both in the shallow water close

inshore and a little farther out, is very nearly the same; at a depth of 20—50 m., the number of males shows a marked decrease, especially among fish of 8 years old or more. This must be interpreted as indicating that these older males have now left the bay and are moving out to the spawning grounds. Compared with the intra-territorial area of Faxe Bay, where the percentage of ♂♂ was greater than that of the ♀♀, Skjálfandi Bay thus shows entirely different conditions (see fig. 69).

Average length of Plaice in Iceland waters, past and present.

As already mentioned, the plaice of the north coast are larger than for instance on the trawling grounds in Faxe Bay. In further illustration of this, and to show that any comparison of past and present average length of plaice in Iceland waters needs to be based on hauls from the same grounds, we have drawn up a graph (fig. 72) for the catches from Faxe Bay and Skjálfandi Bay, both taken with the Danish seine at very nearly the same depth in 1908.

	Average length in cm.		
Faxe Bay: 64° 02′ N., 22° 33′ W.	♂♂	♀♀	Both sexes
26.—27. June 1908. Depth 34 m.	$A_{418} = \mathbf{26.65}$	$A_{323} = \mathbf{27.54}$	$A_{741} = \mathbf{27.13}$
Skjálfandi Bay: 66°01′N., 17′30 W.			
24. July 1908. Depth 19—37 m.	$A_{155} = \mathbf{31.41}$	$A_{156} = \mathbf{35.78}$	$A_{311} = \mathbf{33.60}$.

As the »summer« falls considerably later in the fjords of the north coast than in those of the west, the difference in time (abt. 1 month) between the catches will hardly be of any importance in this connection. The difference in average length between the total catches is very considerable, abt. 6.5 cm., and as regards the two sexes, greater in the case of the females.

With regard to the question as to whether the average length has been affected by the fishery in Iceland waters, we have an isolated statement by A. C. Johansen (1903); this writer considers that no decrease can be discerned in the size of the plaice on the east coast of Iceland, but the slight average size in Faxe Bay suggests that probably over-fishing is taking place there. The Danish fishery investigations in Iceland waters have procured material throwing light on one side of the questions here concerned; the matter is, however, complicated by the partial immunity enjoyed by the fish owing to the recent war, and besides sufficient pre-war otolith-material is not available for age-investigations.

We have records of comparable trawl-catches from Faxe Bay and Skjálfandi Bay for the years 1903, 1908 and 1924. These are shown graphically in figs. 73—74, pp. 166—167, and the average lengths are given pp. 166—167.[1])

[1]) Trawl catches from *Skjálfandi Bay* in 1903 contained quantities of small plaice down to as low as 4 cm, whereas in 1924 these were not found; the mean value for males and females 1903 in Skjálfandi Bay has therefore been calculated from specimens over 22 cm. this being the lowest length of any plaice taken by trawl here in 1924.

It will be seen that the average length of plaice both in Faxe Bay and Skjálfandi Bay is greater for 1924 than for 1908 and 1903 respectively.

The difference between the averages is lowest in Skjálfandi Bay; it will be

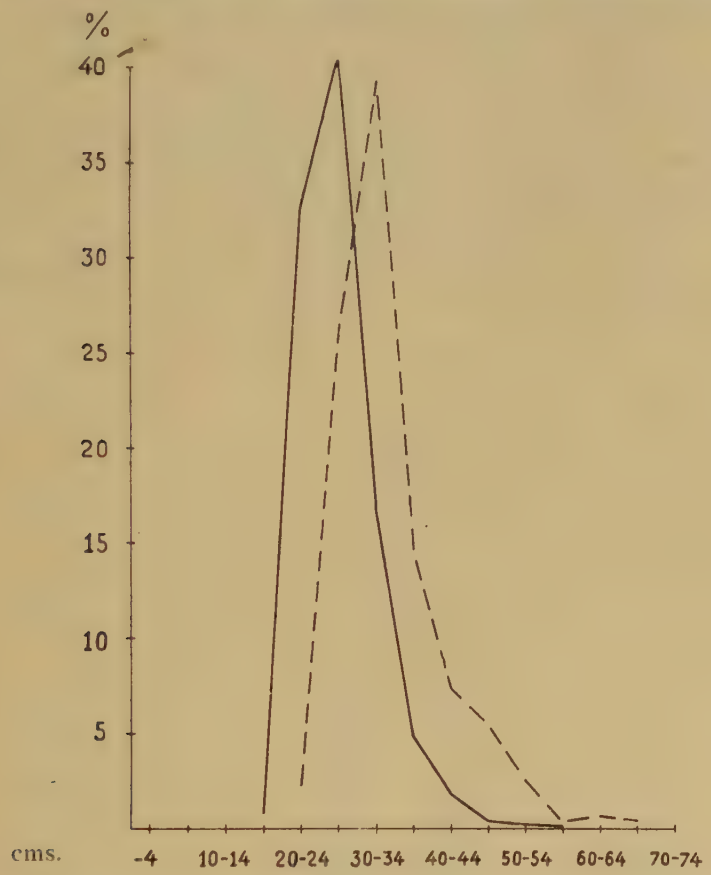


Fig. 72. Curves showing percentage within 5-cm. groups for two hauls with the Danish seine 1908. —— Faxe Bay ——— Skjálfandi Bay.

seen, however, (Fig. 74) that the dislocation between that part of the curves representing the quantities mainly composing the trawl catches in 1924 is considerable, and that the slighter difference between the average lengths is due to the numbers of large plaice over 50 cm. found in Skjálfandi Bay in 1903.

Investigations of recent years (e. g. C. G. Joh. Petersen 1921, K. Smith 1923, S. Strodtmann and H. Langhammer 1925) show that in certain regions, such as the Baltic and others, the average length is greater of late years compared with the pre-war average. This is, as we know, explained as due to the fact that intensive fishery gives the remaining stock better conditions of life.

Faxe Bay:

1908: 64° 16′ N., 22° 17′ W. + 64° 01′ N., 22° 30′ W.

16. June—8. July 1908. 50 feet otter trawl. Depth: 34—68 metres.

Average length of 457 specimens > 25 cm: **31.18** cm.

The entire material shows:

♂♂ A_{293} = 30.13 cm. } Average of 498 sp.: **30.19** cm.
♀♀ A_{199} = 30.22 - }

1924: 64° 04′ N., 22° 35′ W. + 64° 08′ N., 22° 23′ W.

11. June—7. July 1924. 50 feet otter trawl. Depth: 30—37 metres.

Average length of 3958 specimens > 25 cm: **33.59** cm.

The entire material shows:

♂♂ A_{2284} = 32.04 cm. } Average of 4224 sp.: **32.66** cm.
♀♀ A_{1940} = 33.35 - }

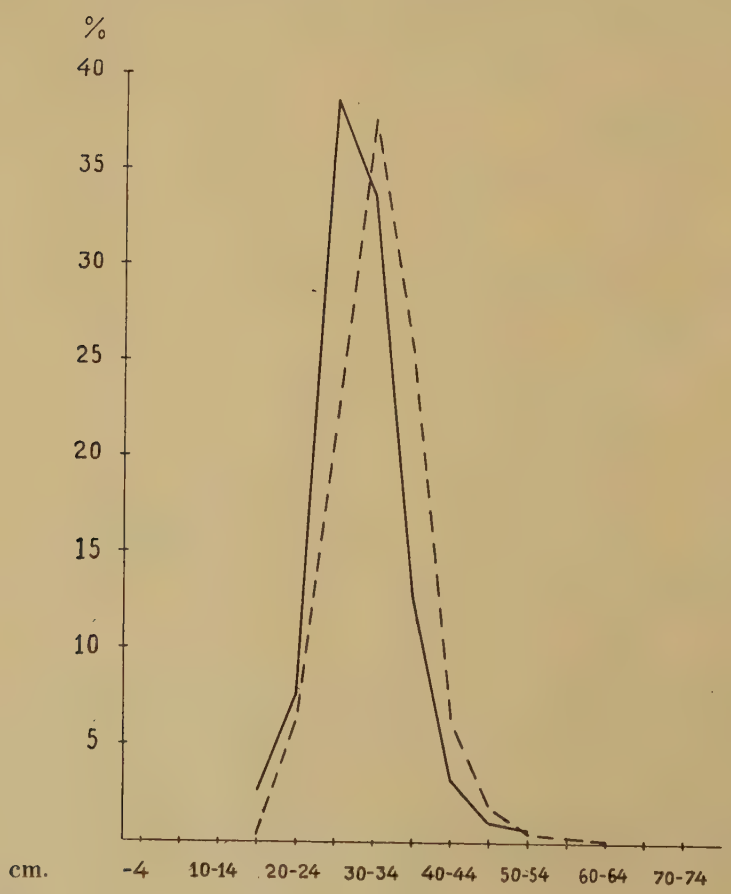


Fig. 73. Curve showing percentage within 5-cm. groups for plaice taken by 50-feet otter-trawl in Faxe Bay.
——— 1908 (»Thor«) — — — 1924 (»Dana«).

Skjálfandi Bay:

1903: Same place as trawling experiments of 1924, *vide supra* p. 160.

19. June—1. July 1903. 50-feet otter trawl. Depth: 6—46 metres.

Average length of 3212 specimens > 25 cm; **37.82** cm.

The entire material shows (see note p. 164):

♂♂ A_{1369} = 32.27 cm.
♀♀ A_{2954} = 40.39 - } Average of 4323 sp.: **37.13** cm.

1924: For position *vide supra* p. 160.

25.—27. July 1924. 50-feet otter trawl. Depth: 7—54 metres.

Average length of 1418 specimens > 25 cm: **38.28** cm.

The entire material shows:

♂♂ A_{449} = 35.53 cm.
♀♀ A_{832} = 39.18 - } Average of 1427 sp.: **38.19** cm.

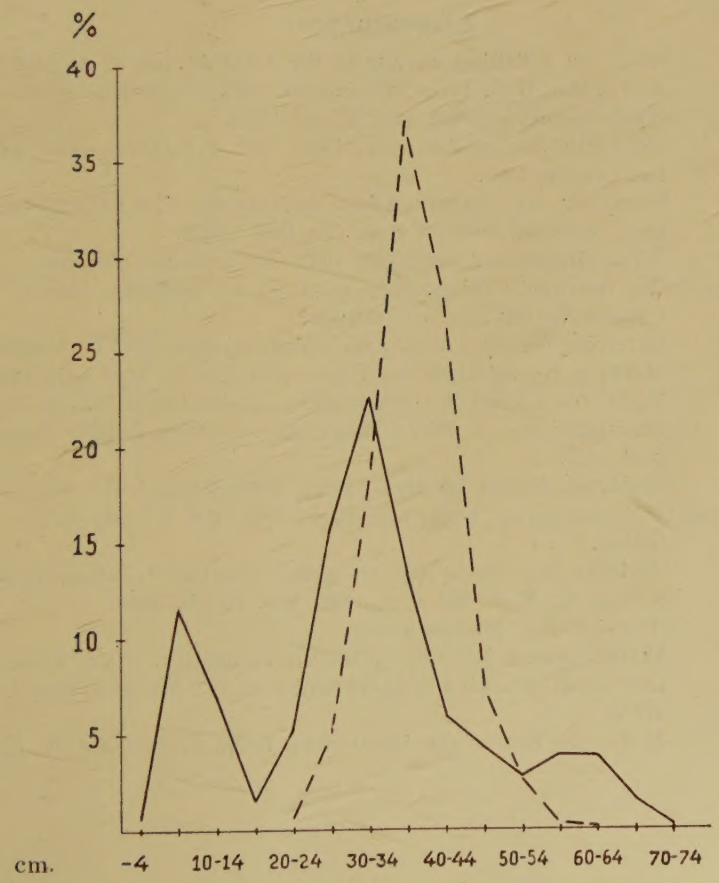


Fig. 74. Curves showing percentage within 5-cm. groups for plaice taken by 50-feet otter-trawl in Skjálfandi Bay.
——— 1903 («Thor») — — — 1924 (»Dana«).

We find then, in Iceland waters, the same feature as in the Baltic and elsewhere; but future investigations must determine whether this is due to the same causes. We would here point out that in regard to Faxe Bay, the section dealing with the Haddock in this report (pp. 149—151) shows that the four lowest year-classes in the 1924-material show a higher average length than the corresponding classes in the 1908-material; all the older year-classes are smaller than in 1908. In the case of other fishes also we find the same thing, as for instance with the youngest year-classes of the Halibut. This, together with the fact that the plaice in intra-territorial Iceland waters, despite the less intensive fishery carried on there, has also increased in size, leads us to suggest that the general increase in average size might perhaps be due to a periodicity in hydrographical or other conditons (food for instance) irrespective of any influence exerted by the fishery.

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